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THE MEDICAL ASPECTS OF AIR RAID PRECAUTIONS WITH
SPECIAL REFERENCE TO THE ORGANISATION OF A CASU-
ALTIES SERVICE FOR A CIVIL POPULATION.

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*With Appendices in crimson cylinder
2½' long.*



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CHAPTER I.

Introduction:-

Although this country is at peace and there is no immediate prospect of war, the outside world is by no means quiet. At the moment there is a civil war in Spain and Japan is engaged in fighting China. Recently the Italian-Ethiopian conflict was raging, and several other smaller engagements have been fought in different parts of the world during the past ten years. With this unfortunate state of affairs prevailing there is no saying when we may suddenly be faced with a state of emergency and for this we must be prepared. We are not, however, concerned here with politics; but the fact remains that war is always a possibility.

The object lesson in full view of the public today is evident in the recent attacks made from the air on defenceless civilian populations in Spain, and in the wholesale massacres which are being caused by the Japanese air forces when attacking Chinese cities.

It is understood by the British authorities that no chemical agents, other than explosives or incendiaries, are being used in either conflict, but reports indicate that a vast number of casualties are being inflicted on urban communities by bomb and machine gun bullet.

It was stated by neutral observers that the Italian forces sprayed mustard gas from the air during the recent war in Abyssinia, but this was denied by the Italian authorities who however, did admit to having attacked native towns from the air with explosive bombs which caused great loss of life.

The air raids which were conducted by the Germans on British towns between the years 1915-1918 failed in most instances to produce a high quota of casualties, but methods have changed, aeroplanes have improved, new types of destructive agents have been evolved, and a much larger casualty list can be expected in wars of the future.

Some two years ago when the Government changed their policy from one of disarmament to one of re-armament it was realised how exposed the majority of British towns were to attack from the air should war be declared. A new Department was formed at the Home Office with an Assistant Under Secretary of State in charge to set up an organisation for the defence of the civil population. Not the least important side of the organisation was the Medical one, and officers were appointed to create a net-work of Air Raid Casualty Services all over the country. Local governments were advised that they must prepare defence schemes of their own, but that the Government would help, in the first place with advice on technical and training matters, and later, when schemes were prepared, with grants of money.

It is with the organisation and medical administration of a local Air Raid Casualty Service that we are concerned in this thesis.

The preparation of a Scheme for the defence of a military population is no new problem, but never before in England have we had to organise a vast scheme for the protection of our civilians. The work is really a new branch of Public Health and should war arise would be a very important one.

The medical administrator is not concerned with questions of police, air wardens, gas detection, repairs to mains, and the upkeep of essential services, except where these directly affect his immediate aspect of the situation. He is however, concerned with the organisation and administration of a medical service which will collect, treat, and dispose of injured, gassed and chemically contaminated members of the public. He is also concerned to some extent with the protection of the public both in the home and the factory.

Before an efficient organisation for dealing with Air Raid casualties can be created the organiser must have a very full and comprehensive knowledge of all the agents, both chemical and otherwise against which he may have to contend.

In particular the medical administrator must have an intimate knowledge of the pathology and treatment of all injuries likely to be met with. One part

of this thesis therefore is devoted to a description and discussion, with reference to certain literature, of the pathology and treatment of war gas poisoning. The general characteristics and properties of these agents are described in brief, but the medical aspects are discussed in some detail.

The writer of this thesis served as a Regular Officer in the Royal Army Medical Corps for seven years, and had the privilege of attending a gas course for Instructors at the Army School of Chemical Warfare, Winterbourne Gunner, which lasted over four weeks. Subsequent service as a Gas Instructor, both in the Army and to the British Red Cross Association, afforded further experience on chemical warfare matters. When the author retired from the Service ⁱⁿ 1933, and entered general practice in Leicester he still found opportunities of giving lectures to interested civilian bodies. In October 1936 he was approached by the Health Committee of the Leicester Corporation, and asked to take over all duties concerned with Air Raid Precautions which came under the Medical Officer of Health. He was given the appointment (part time) of an Assistant Medical Officer of Health, and in December 1936 represented his chief on the course of instruction for Senior Medical Officers held at the Civilian Anti-gas School, Falfield, Gloucestershire.

During the past year the writer has been engaged in working out his scheme for the City of Leicester

concerning the organisation of Air Raid Casualty Services. This has been done in conjunction with Office Officials and the heads of the other Departments who are concerned with their own particular aspect of the general scheme.

The subject matter of this thesis has been obtained from the writer's own experience and from a study of assorted literature on the subject, including a number of Home Office publications from the Air Raid Precautions Department.

The British general public is terribly ignorant of the true aspect of modern chemical warfare, and varies in its belief from the view that no harm can accrue, to the view that a bomb dropped in Piccadilly Circus could liberate enough gas to asphyxiate the whole of London. Even ex-soldiers, who had experience during the War have only a vague idea of the different gases and their results. In recent years the popular press has published unscientific articles which have been believed in toto by the general public. Much education is required to correct impressions already formed by the individual, and it must be remembered that the average person does not read books on the subject. The bulk of the education of the people must be done through sane newspaper propaganda and through the general discussion of chemical warfare matters by people who know. The medical practitioner, with the influence of his professional status, should make it his duty to acquaint himself with a sound knowledge of the nature and

treatment of war gas casualties so that he can speak with authority in time of peace when reference is made to the dangers of gas in war. A doctor should be prepared to be consulted by his patients on this matter.

Success in military warfare when gas is used depends either on the element of surprise, or on the lack of disciplined training among the troops on whom it is used. The same would apply to civilian populations, and an urban community, well trained and disciplined to follow defensive procedures, is not only largely insured against gas injuries, but it is also insured against panic, which, in densely populated areas, is a potential source of major disaster.

According to Prentiss (2) "there can be little doubt that elaborate defensive drills, conducted during recent years in such cities as Tokio, Berlin, Moscow and Vienna have been motivated in part by the desire to demonstrate to all likely attackers that precautionary measures of passive defence are elaborated to such a degree as to render air raiding a barren and futile undertaking. While such exhibitions may never serve to wholly deter attack, they must still inevitably influence military decisions as to the selection of targets and of the means of their assault."

Prentice goes on to say that the primary mission of air force is the destruction of an enemy's military strength, and no serious risks are to be accepted that do not directly serve this end. It is obvious there-

fore, that air attacks against civil communities which are prepared, will not be so effective as those against an unprepared population, and the "prepared" factor may be the final influence which determines whether or not it is worth while attacking an individual city. Any community which is well trained and well prepared to counteract the effects of aerial attacks ceases to be an inviting target.

Any large scale raid against urban communities involves not only a tremendous expenditure of material, but also a very serious diversion of military effort from more immediate, and possibly more important objectives.

The chemical agents that may be employed in the aerial attack of cities are, so far as can be foreseen from the present evolution of gas warfare, no more than the following :- vasicants such as mustard and Lewisite; lung irritants, such as chlorine and phosgene ; irritants in the form of tear or sneeze gases; smokes; incendiaries. Most of these chemicals must be dropped in bombs, and only liquids of the mustard gas type may be sprayed from air-craft. According to Prentiss both methods are governed by technical limitations so rigid that the areas that can be directly subjected to gas in any single attack represent no more than a fractional part of the average metropolitan district.

It is difficult to maintain a lethal concentration of gas for any extended period of time by means of bombs dropped from rapidly moving aeroplanes. It is estimated that the equivalent of one three hundred pound gas bomb is required for each circular area of two hundred yards in diameter. Even this will only produce an effective result in the case of phosgene for a matter of a few minutes, and it is obvious that this is a most expensive method of attack.

The effective spraying of liquid chemicals will be seriously affected in the case of urban districts by the fact that the population will be under roof cover, and will not be likely to be directly contaminated in any numbers.

Of the known chemicals, incendiaries probably present the greatest danger from aerial attacks. To retard the work of firefighters gas may be of value as a means of spreading peril and panic, and of disorganising the main public services. It is in obviating these possibilities that Air Raid Precautions have their greatest value.

CHAPTER II.

CHAPTER II.BRIEF HISTORY OF "RULES OF WARFARE".

Without going too far back into History, it may be mentioned that a few years before the outbreak of the Great War the question was examined in this country of the possibility of poison gases being used in warfare, but the matter was shelved in view of the wording of the Hague Convention which was as follows :-

"The contracting powers agree to abstain from the use of projectiles, the sole purpose of which is the diffusion of asphyxiating or deleterious gases." Later, in 1913, it was held on high legal authority that a double purpose shell, i.e., one which contained a small portion of lachrymatory substance which had no asphyxiating or deleterious effect might not be considered to infringe the word of the Convention. The Hague Convention also made allowance for the gases which are of necessity released from high explosive shells, bombs etc., but the intention was to prohibit the use of any poison gas as such.

Prior to the era of modern times there do not seem to have been any generally recognised limits to the scope and character of warfare, on the contrary, might made right where war was concerned, and any means of defeating the enemy was considered justifiable.

The first code of warfare which sought to define the limits of armed conflict between civilised races were the Rules made for the armies of the Union in the American Civil War 1861 - 1865. These Rules eventually became the basis for what we now know as the Rules of

Land warfare, and are nominally accepted in principle by all the civilised nations.

It is now a matter of history that on the evening of the 22nd of April, 1915, at 5/30 p.m. near Langemark the Germans released a dense cloud of chlorine which floated over the French Lines, and produced many casualties among the French Colonial Troops. This action was of course, a flagrant breach of the Rules of War as laid down by the Hague Convention. The German Authorities, however, alleged that the French, on the other hand, were the first to use chemicals, and claimed to have suffered casualties as a result of gas shells. The French reply was that no gas had been used, but that any such casualties were caused purely by poisons formed as a direct result of an explosion.

The first gas attack on British Troops, occurred a few days later,^{and} when the news reached the British Commander in Chief he wired to the Cabinet for permission to retaliate, but this was not at first granted. The War Minister apparently had some difficulty in obtaining Cabinet sanction for undertaking reprisals because it was not until the 18th May, that he announced in public that protection must be given to our troops by the employment of similar methods. Even then it was to be understood that "only gases were to be used such as were harmful, but not much more so than those used by the enemy". The above is an illustration of the attitude adopted by the British in the early years of the

war, which however, in view of the continued ruthless attacks made by the enemy, soon changed, and units were formed with the definite purpose of taking the offensive in the use of chemical agents against the Germans.

Foulkes (1) in his recent book states that the majority of the German people are still said to firmly believe that the Allies were the first to use gas, and as some ignorance on this subject perhaps still exists in this country, he has shown what little basis there is for the contention. He states that our entire ignorance of the whole subject was particularly evident when the question of retaliation came to be considered, and very little help was available at the beginning, even from our most eminent scientists.

It is interesting to note how the attitude of the high powers changed when confronted with a crisis in the stress of war. Such things have happened before, and despite the articles of the League of Nations may happen again.

During the whole period of 1914-1918 no gas of any sort was used by the Air Force of either side, but whether this would happen again is a matter of extreme doubt.

The use of chemicals against civilian population as a means of influencing the course of a war has never been attempted, and the possibilities of this prospective feature of modern warfare must remain speculative. Meanwhile, as has already been mentioned, raids are being carried out in Spain and bombs dropped on

defenceless non-combatants, but no gas is being used. It is believed that if war gases were used they would be sufficiently powerful to accomplish widespread destruction in any unprotected civil community against which they might be launched.

The only treaty on chemical warfare which has been ratified since the Great War, is the Geneva Gas Protocol of 1925, and it should be noted that it was not agreed to by the Argentine, Brazil, Czecho-Slovakia and Japan.

CHAPTER III.

CHAPTER III.METHODS OF AIR ATTACK.

Different methods of attack from the air consist of bombs, chemical spray and machine gun fire.

Bombs:-

1. High explosive bombs.
2. Incendiary bombs.
3. Gas bombs.

1. High explosive bombs are very heavy and very expensive to manufacture, and the Government is of the opinion that they will not be dropped indiscriminately, but aimed at an objective. They depend entirely for their action on their "blast" effect, and are capable of destroying not only the building on which they fall, but of wrecking property in the vicinity.

2. Incendiary bombs are filled with a compound which is ignited when the bomb strikes a hard surface. The case of the bomb itself may be composed of inflammable material, such as magnesium, and since these bombs contain within themselves the necessary elements for combustion, they cannot be easily smothered. It is anticipated that a small incendiary bomb, weighing two lbs. may be used, and this will normally pierce the ordinary type of roof, and will ignite on the floor of the top storey. Such a bomb would be particularly dangerous, as it could be used in large numbers, over a thousand can be carried by a single bombing machine. An

An incendiary bomb of this type can only be extinguished by the use of dry sand, and preparations are being made to educate house-holders as to how this can be done. A very severe type of burn, both deep and extensive can be caused by this weapon, the treatment of which will follow the ordinary lines with 2% Tannic acid solution applied either by spray or compress.

3. Gas Bombs. All chemical agents used in this class of warfare are described as being a "gas" irrespective of whether they are in the solid, liquid or gaseous state.

Gases are further divided into two main groups, non-persistent and persistent, depending on the length of time during which they continue to have a toxic effect.

For the education of the public they may be classified according to the effects which they produce upon the human body. These groups are designated by the following names :-

1. Lung irritant gas.
2. Nose irritant gas; (or sternutator)
3. Tear gas (or lachrimator.)
4. Blister gas.

1. Lung Irritant Gas:-

This group includes the following:- chlorine, phosgene, diphosgene, chlorpicrin, ethyldichlorarsine, methyldichlorarsine. All of these, with the exception of phosgene have in addition a lachrymatory effect.

During the Great War, it was found that phosgene was by far the most toxic of this group, but that a phosgene cloud was very easily dispersed. In practice a mixture consisting of equal parts of chlorine, and equal parts of phosgene was found to be most successful, and it is likely that some mixture of this nature may again be used in the future.

These two gases will be taken in greater detail later in this thesis, when the pathology, clinical effects and treatment will be discussed.

2. Nose Irritant Gas:- American authorities apply the term sternutator to this class of chemical agent which includes the following :- diphenylchlorarsine, diphenylcyanarsine, and adamsite or diphenylamine-chlorarsine.

Of these the last is by far the most efficient, and is effective in very slight concentrations. It is known in chemical warfare circles as D.M. and will be described in detail later as it is thought that this may be used against civilians as a means of producing panic without being lethal.

3. Tear Gas:- This group includes the following:- bromacetone, brombenzyl cyanide, chloracetophenone, and ethyliodoacetate.

Of the above chloracetophenone or C.A.P. is used for training purposes in this country, and is also used by the authorities in certain foreign countries for

dispersing mobs. It is not, however, likely to be used during a war as its lachrymatory effects are soon lost by reason of the condensation of the substance to the solid inert state soon after the initial dispersion.

Ethylchloroacetate or K.S.K. is the most likely lachrimator to be used and will be discussed in detail later.

4. Blister Gas:- This group includes:- mustard or dichlorethyl sulphide, Lewisite or chlorovinylchlorarsine, and methyldichlorarsine ; Of these the first two will be described in detail.

In addition to the above certain other chemical agents were tried out by both sides during the Great War, including hydrocyanic acid, and hydrogen di-sulphide. These are absorbed and act as systemic poisons. They are extremely toxic, but were found to be of little use in actual practice in the field, although the French persisted in the use of the former right to the end of the War.

It is not considered likely that either will be used in the course of air raids.

It is therefore concluded, that the most likely chemical agents to be included in aerial bombs will be (1) a mixture of chlorine and phosgene or pure phosgene; (2) D.M.; (3) K.S.K.; (4) Mustard; (5) Lewisite. Aerial spray may include mustard and Lewisite, which may be scattered in small droplets over large areas from aeroplanes fitted with special tanks.

With the exception of Lewisite all of the above gases were fully tried out during the Great War, and were found to be the most useful, each in its own class. Lewisite was discovered in 1918 and was never used in practice, but experiments show that it may present a dangerous weapon. To the best of our knowledge no other efficient chemical agents have been discovered despite the reports which have appeared from time to time in the sensational press. Each "discovery" on investigation has invariably revealed some weakness which has led to it being discarded as a practical proposition.

CHAPTER IV.

CHAPTER IV.CHLORINE AND PHOSGENE.

As has already been stated chlorine was the first chemical agent to be used in the Great War. It was then exploited in the form of a cloud, released from cylinders in the German trenches and blown across to the Allied lines by a favourable wind. Since then it has been used in projectiles of different sorts, but has the disadvantage that a special lining is required to prevent the erosion of the metal container. Chlorine is easily liquified, and when released quickly forms a dense vapour cloud which is not so easily dispersed as other gases.

It is very highly irritant to the linings of the nose, larynx and bronchi and a marked feature of its action is the cough which it produces almost immediately. The eyes are also affected and intense lachrymation is produced even in light concentration.

Phosgene is estimated as being ten times more lethal than chlorine. This gas is a liquid which boils at 46.8 degrees Fahrenheit with the evolution of a dense colourless vapour. It is not so immediately irritant as chlorine, but is readily detectable by its smell which resembles that of musty hay. More than 80% of gas fatalities in the World War were caused by phosgene.

Phosgene vapour is 3.5 times heavier than air, while chlorine vapour is 2.5 times heavier than air, so that either separately, or as a mixture a cloud of these gases clings well to the ground, especially when travelling down hill.

The lethal concentration of chlorine for thirty minutes exposure is 2.53 mg. per litre, and for ten minutes exposure 5.6 mg. per litre. The lethal concentration of phosgene is 0.5 mg. per litre after ten minutes and in the higher concentration which may be met with immediately after the gas is released, one or two breaths may be fatal.

Apart from its characteristic odour, phosgene may also be detected in the field by its so-called "tobacco" reaction, by which it is meant that men who have inhaled even minute amounts of phosgene complain of a bitter metallic taste when smoking a pipe or cigarette.

A feature of the action of phosgene is its insidious action, and occasionally there are several delayed effects.

The intense spasm which may be induced by a single breath of a heavy concentration of phosgene, or a mixture of phosgene and chlorine, may interfere with the quick adjustment of the protective respirator.

The three types of respirator manufactured and issued by the British Government to Air Raid Personnel and to civilians afford complete protection against this group of gases as soon as the respirator face piece is properly adjusted.

All lung irritant gases cause the same type of damage, this being most pronounced on the pulmonary alveoli and the smaller bronchial tubes. The great danger to be feared is the onset of acute pulmonary

oedema, the severity of which depends on the concentration of gas inhaled.

In discussing the morbid anatomy of cases following lung irritant poisoning, a description of conditions found where, (a) death has occurred in the first twenty-four hours; (b) on the second or third day; (c) or on the fourth day, will be given.

The essential lesions are pulmonary oedema, rupture of the pulmonary alveoli, concentration of blood with increased viscosity and a tendency to thrombosis.

The following descriptions were obtained from The Official History of the Great War and the references are given in the Bibliography. (3).

a. When death occurred in the first twenty-four hours the lungs were voluminous, and hardly collapsed at all when the thorax was opened, but bulged forward so as to partly cover the area of pericardium normally left free. Distended lymphatics and small sub-pleural haemorrhages were frequently visible on the lung surface. Air which had escaped from the damaged lungs was often visible as chains of bubbles below the visceral pleura, along the interlobar fissures, and even occasionally penetrating the mediastinum.

The pleural cavity almost invariably contained a quantity of serous, and sometimes blood stained effusion, varying in amount from one ounce to twenty ounces. It is impossible however that much of this fluid had exuded from the oedematous lungs after death. In

every case the lungs on removal from the thorax were very heavy, generally about twice the normal weight.

When sectioned, the intensity of the pulmonary oedema and vascular congestion were at once made evident by the frothy serous fluid and dark blood that dripped abundantly from the cut surface. Irregular alternating patches of collapse and acute emphysema extended through the lung substance. Occasionally infarcts were seen here and there.

The trachea and bronchi were filled with thin yellow, and highly albuminous fluid, which was found escaping from the mouth and nostrils after death, as a white froth.

In cases where chlorine had been the casual agent, the mucous membrane of the larynx, trachea and bronchi was intensely congested and deep purple in colour. The epithelium was swollen and the submucous tissue oedematous.

The mucous membrane of the pharynx was abnormally dry and glossy, and somewhat congested.

In cases where pure phosgene appeared to have been the casual agent, the mucous membrane of the upper trachea and larynx was apparently unaffected, and the inflammation confined to the bronchi and lower trachea. In a few cases even the bronchi appeared to be completely unaffected, although there was severe alveolar oedema present.

b. When death occurs on the second or third day after exposure, the aeration of the lung is much greater than that found on the first day. This is particularly marked on the lower lobe of each lung.

Serous fluid does not drip nearly so freshly on section as in the former type, but the oedema tends to persist in the upper lobes.

c. When death occurs on the fourth day or subsequent day after exposure there is no dripping of fluid when the lung is sectioned. There are generally several greyish patches of definite broncho-pneumonic consolidation and commencing pleurisy, in other words secondary infection has commenced to set in.

From the above description of the morbid anatomy of the lung it is obvious that the oedema commences to be absorbed from the second day onwards.

The following observations were made on the morbid anatomy of the circulatory system. The large veins were gorged with blood and the right side of the heart was usually distended. Petechial haemorrhages were seen in the pericardium, and the pericardial fluid was increased in amount.

The stomach showed presence of petechial haemorrhages and occasionally slight ulceration of the walls had occurred.

The liver and kidneys were invariably congested, but no other lesions found.

In cases of early death the brain showed congestive

changes, and in later cases Mott (4) has described the presence of petechial haemorrhages and areas of cyanosis throughout the white matter. These haemorrhages were particularly frequent after phosgene poisoning, and in a few instances there were large and fatal haemorrhages as early as the first or second day after exposure.

Microscopic examination shows the whole lung to be affected by oedema, and it was seen that the oedematous fluid contained desquamated alveolar cells. There was extravasation from the smaller vessels, but very little fibrin could be detected. In some areas of the lung the alveoli were completely filled with fluid and the capillaries congested, while in other areas the fluid was very much less in amount. The emphysematous areas were not only due to hyper-distension of the alveoli, but also to actual tearing of tissue, the ruptured ends of the walls being clearly visible. Nectoric changes in the cells of the alveolar walls could usually be seen.

From the third day onwards patches of bronchopneumonia could as a rule be identified.

Microscopic examination also revealed the frequent occurrence of local thrombosis in the capillaries of the lungs, and this probably occurred elsewhere in other organs, such as the kidney and brain.

American observers, Meek and Eyster (5) have made experiments on the agglutination of red blood corpuscles *invitro* when phosgene is bubbled through a

suspension. They have come to the conclusion that the obstruction of the pulmonary circulation was not due merely to stasis, but to an actual clumping of cells under the direct influence of the gas.

Both British and U.S. experts agree that phosgene is not absorbed into the blood stream owing to the fact that it decomposes in water.

Dunn (6) has conducted a series of experiments on goats. Each goat was given varying dosages of phosgene sufficient to cause serious illness, and 60% of them died from pulmonary oedema. Others were killed in the early stages and various observations were made. It was found that for the first half hour there was no pathological change, but at the end of the period there was some reddening of the centres of the lobules of each lung. Following this oedema quickly developed in the interstitial tissues and opened up the interlobar plane. Alveolar oedema could always be seen after half an hour by microscopic examination. The fibres of the intrt-lobular plane, as well as the paribronchial and periarterial connective tissue were found to be widely separated by fluid, and the lymphatic vessels in these situations were dilated.

Edkins and Tweedy (7) believe that this distension of the lymphatics by fluid indicates a reabsorption of the oedema through these channels, fluid only accumulating in the alveoli when exudation from the capillaries can no longer be balanced by absorption.

Lehmann (8) originally put forward a similar view in his work on bromine and chlorine which was published before the War.

Dunn, in his goat experiments, found that the real damage is done from half an hour to four hours after exposure, and is effected mostly on the capillary blood vessels. The only change in the epithelium of the bronchial tubes at this stage was an alteration in the staining capacity of the cells.

The oedema became more intensive during the next few hours, and large areas of the lung became entirely filled with fluid to the exclusion of all air and fluid^{was} found in the pleural cavities in every case. At the end of forty-eight hours after exposure the lung was differentiated into areas of solid oedema and areas of emphysema.

A goat killed one month after exposure showed no sign of any lesion..

The following is a table which summarises Dunn's work. The mean lung-heart ratio referred to is the weight of the lung in pounds divided by the weight of the heart in pounds. In the normal goat this ratio ranges from 1.5 to 3.

| | 1st | 2nd | 3rd | 4th | 5th. |
|-------------------------------|------|------|------|------|------|
| <u>Day of Death.</u> | | | | | |
| Number of Deaths. | 54 | 30 | 12 | 6 | 1 |
| % Total Deaths. | 52.5 | 29.1 | 11.6 | 5.8 | 1 |
| <u>Mean Lung-Heart Ratio.</u> | 8.15 | 8.70 | 6.55 | 4.84 | 4.80 |

It is evident therefore that by far the majority of the deaths occurred on the first day, while the mean lung-heart ratio was highest on the second day, and rapidly declined during the following forty-eight hours.

Exposure to an atmosphere containing phosgene or chlorine may lead to three types of casualties.

- a. Acute with violent onset.
- b. Acute with insidious onset.
- c. Chronic.

Chronic cases of lung irritant poisoning only occur in factories or dye-works, and are not dealt with here.

Acute Cases with Violent Onset are generally seen after exposure to chlorine or chloropicrin, but phosgene in an effective combination will produce a similar picture.

There is immediate sensory irritation of the respiratory passages, accompanied by choking and coughing and a sensation of pain in the chest. The breathing is shallow and rapid even after the patient leaves the poisoned atmosphere, and any attempt to draw a deep breath gives rise to painful discomfort and cough. Retching and vomiting are prominent features, and all patients complain of a feeling of lassitude which renders them helpless.

With the onset of oedema the breathing becomes more rapid and panting. The ear, lips, and eventually the whole face assume a purple red colour. The finger nails become livid. Arteries and veins are distended. The pulse is full and increases its rate up to 100 per minute. The chest is now only moved by the diaphragm and the respiratory rate may increase up to eighty per minute.

The vomiting now ceases, but the cough remains frequent, though shallow. There is no odour in the breath.

The percussion note over the lung remains resonant, except over the bases. On auscultation the breath sounds may be harsh and noisy, or feeble. If oedema is present there may be fine crepitations or rhals. In the early stage the physical signs give very little indication of the gravity of the case or the extent of the damage to the lungs.

The patient expectorates a yellow albuminous fluid which later turns to a thick viscous primrose yellow sputum often streaked with blood.

The lips are parched and the tongue is heavily coated. The skin is dry.

In the early stages the temperature is subnormal, but later may rise to 101° F.

In the chlorine poisoning the purple red colour of the face and extremities goes on to a full cyanosis which may, or may not be present in cases of phosgene

poisoning. In the latter the patient may pass rapidly into a state of collapse with a feeble pulse of over 120, a cold clammy skin and leaden hue of the face. In both these types of asphyxia the onset of cyanosis is marked by increasing breathlessness and apprehension.

Apart from the fulminating cases in which death follows within two or three hours after exposure, lung irritant casualties can be divided into three types.

1. The milder case with flushed face, painful cough and rapid respiration.
2. The severe case with blue cyanosed face, distended neck veins and full strong pulse of 100.
3. The severely collapsed case with leaden "grey" cyanosis of the face and rapid thready pulse.

For practical purposes they may be classified as "red", "blue", or "grey" faces.

The milder case is often drowsy and soon falls into a deep sleep from which he wakes feeling refreshed. After thirty-six hours he feels much better, and beyond complaining of a slight rawness in the throat, coughing after a deep breath and occasional vomiting after food or drink has no real ill effects. A feeling of general debility may persist for a few days during convalescence. Frequently there is a considerable slowing of the pulse which, however has no serious import, and is generally regarded, on the other hand, as a good sign.

The "blue" type of case, where the pulse does not exceed 100 tends to recover after two or three days. Provided that the circulation and activity of the respiratory centre can be maintained, the oedematous fluid in the lungs is soon absorbed, most of it vanishing by the fourth day. At any time, however, these cases may rapidly pass into the more dangerous condition of "grey" cyanosis and collapse. The patient becomes obviously weaker, more restless and semi-conscious. Even the worst of the "grey" cases may recover with proper treatment, but the mortality is always very high.

"Blue" or "grey" cases may, under proper treatment, be showing signs of recovery from pulmonary oedema when the severe and often fatal complication of infective broncho-pneumonia may set in. When this develops the sputum becomes purulent and the temperature rises, and death usually follows. If however, the patient lasts into the third week after gassing he may be expected to survive the infection.

Statistics show that the majority of deaths due to poisoning by phosgene and chlorine occurred within twenty-four hours of exposure.

Acute Cases with insidious onset:-

It was not until the 19th December, 1915, some eight months after the Germans first used gas, that the possibility of delayed or insidious onset was realised.

(9) Cases were reported in which men who had been

exposed to gas had been able to carry on their work for an hour or two and then had passed into a condition of collapse with progressive oedema of the lungs, which in many cases proved fatal. Foulkes (10) describes a case when a sergeant got a slight dose of gas the day after an attack had been made, while disconnecting pipes from empty cylinders. The sergeant paid no attention to it and did not even mention it at the time and carried on with his duties. He slept and breakfasted well on the following day, but an hour later he became very ill, and died twenty-four hours after first inhaling the gas.

Other cases have been described in which men have died some hours after exposure on attempting to perform some vigorous muscular action.

In these cases the patient becomes blueish about the lips, and coughing produces a frothy sputum. The lips and face quickly become cyanosed and the case rapidly becomes "grey" in type. It is seldom that there is any great struggle for breath, and the patient may die without realising how ill he is.

Physiological Factors in relation to Symptoms and Treatment:-

It has already been pointed out that severe cases of poisoning by lung irritant gases fall into two groups, i.e., the "blue" and "grey" types. The common feature of the two groups is the cyanosis which indicates that in each the patient is suffering from profound shortage

of oxygen. It is this factor which endangers life, and of the two cases the "grey" is clinically of far more serious import.

In the case of concentrations of lung irritant gas met with in practice the whole of the gas appears to be stopped by the tissues of the lung and none penetrates, as such, into the blood stream. In bearing the brunt of the attack the respiratory organs suffer severe damage, and the asphyxial symptoms must be attributed to this.

It is easy to see that a layer of oedema fluid must seriously interfere with the gaseous exchange between the blood and the air in the lungs, and the difficulty is increased by thrombosis of the damaged pulmonary capillaries. Carbon-dioxide is a far more soluble gas than oxygen and so will diffuse through a layer of liquid much more quickly. It can therefore be imagined that the pulmonary oedema seriously reduces the rate at which oxygen can enter the blood, without causing much impediment to the passage of carbon-dioxide in the reverse direction. The picture of a severe phosgene case is thus a gross anoxaemia with no carbon-dioxide to stimulate the respiratory centre which begins to fail, and the heart to weaken. A vicious circle is now established, and unless this can be broken the patient's condition grows weaker and leads to death.

In cases of lung irritant poisoning accompanied by great sensory irritation of the upper respiratory

passages and vigorous coughing there is far more obvious inflammation and spasm than in the case just described. The violent respiratory movement resulting from the coughing and the efforts to draw breath tend to tear the damaged lung tissues so that areas of emphysema and of collapsed lung are formed. The normal ventilation of the lung is thus interfered with, for the collapsed areas cannot be adequately supplied with air, and thus the elimination of carbon-dioxide is impeded as well as the absorption of oxygen. The case will now exhibit the features of anoxaemia, accompanied by retention of carbon-dioxide which is a natural stimulus to the respiratory centre, and its presence in excess helps to maintain the action of the heart and the tone of the circulation. The deep cyanosis still indicates great shortage of oxygen, but the heart beats at a slower rate and far more steadily and powerfully. The obvious venous congestion however, shows that the heart is feeling the strain, and the circulation as a whole has to contend with yet another difficulty, i.e., concentration and increased viscosity of the blood. This last factor is shown by a considerable increase in the red blood cell count, and the haemoglobin percentage. It is caused partly by the passage of fluid into the lungs, and partly by the passage of plasma from the capillaries of the body into the tissue spaces, a phenomenon always observed in conditions of "shock" accompanied by a falling circulation.

The above considerations suggest possible lines of treatment; an attempt may be made to compensate for the hindrance of the passage of oxygen into the blood by increasing the concentration of oxygen in the lungs. If there is a shortage of oxygen when the patient is at rest muscular exertion will increase the body's demand, and so can do nothing but harm. Similarly exposure to cold, results in increased metabolism, and has a like effect. Marked venous congestion suggests the possibility of venesection, and the concentration of the blood makes it worth while considering whether intravenous infusion of saline may be beneficial.

Treatment of Poisoning caused by Lung Irritant Gases:-

It is essential that all treatment of gas casualties should be undertaken and supervised by persons who thoroughly understand the nature of the injuries involved. Medical Officers and General Practitioners will require special training, and it is suggested that doctors who had experience of gas during the Great War should, as far as possible, be placed in charge of gas casualty Wards in Hospitals.

The first difficulty in the milder type of case is to decide whether it requires hospitalization or not. The seriousness of improper diagnosis requires careful observation of every suspected case. This may be extended to as long as forty-eight hours, but if no objective symptom has developed at the end of this period,

the patient may be discharged for treatment in his home. If, during this period it is found that the patient can smoke a cigarette with relish it is unlikely that he has been exposed to any serious concentration of lung irritant.

Many individuals will think they have been gassed, when they may have merely smelt a trivial concentration of gas in the air, but the following facts should help to decide quickly who are gassed, and who are not. Definite choking accompanied by violent coughing, or a strong tendency to cough, and probably by some irritation and watering of the eyes would suggest positive gassing. Vomiting, rapid pulse, congestion of the face and shallow rapid breathing may, or may not, be present in the early stages, but if so would afford additional help in making a diagnosis. A patient who is suspected as having been exposed to one of these gases should be carefully questioned with a view to finding out whether the quantity of gas inhaled has been such as to cause serious injury. If it is possible to smell phosgene or chlorine on a person's clothing, it may be taken that the person has been exposed to a significant dose of the gas. Where there is doubt, precautions must be taken on the assumption that gassing has occurred. If it can be determined that a person has not received a significant dose of gas he should be advised to return quietly home and lie down, and to obtain medical advice if he has not fully recovered by the next day.

First aid treatment of a definitely gassed case consists of protecting the patient from cold and laying him on a stretcher. He must not be allowed to walk, and absolute rest is necessary. In the milder cases hot coffee or tea will be appreciated, and the patient should be placed if possible where he can breathe copious quantities of fresh air. Oxygen is administered to the severe cases, and a decision must be arrived at whether the patient is to be evacuated to a Hospital or not.

On arrival of the patient at a Hospital all garments must be removed and exchanged for Hospital clothing. The patient is then put to bed and attention must be particularly given to keep him warm. Warmth will not only help to combat shock but will diminish any tendency to the muscular movements of shivering. The patient must not be allowed to leave his bed for any purpose whatsoever until all symptoms have subsided. Cases of the "red" type will probably not require any further treatment.

There is no doubt that venesection greatly benefits cases of the "blue" type with a full pulse and signs of venous engorgement. Up to twenty ounces of blood should be slowly withdrawn by means of a stout needle from a vein in the arm or leg. In many cases this affords immediate relief. Headache, a frequent symptom, often disappears, dyspnoea is somewhat diminished, and sleep follows. By this procedure relief may

be afforded at a critical moment when the right side of the heart is beginning to give way under the strain.

Venesection is strongly contra-indicated in the "grey" type of case, which shows pallor and collapse; and failure to recognise this distinction resulted in many unnecessary deaths in the early days of the Great War.

Venesection was first recommended by Macauley(11) who had had some experience in cases of poisoning with nitrous fumes in the South African mines before the War. Macauley had investigated the subject in 1905, and when faced with phosgene poisoning in France in 1915 he found it beneficial.

Hebblethwaite (12) and others fully investigated this line of treatment, and soon there was an impression amongst Medical Officers at the Front that early venesection, in selected cases of phosgene poisoning, was of value.

Later in the War, Underhill, Goldsmith and Wilson (13) investigated, by experiments made on animals, the effects of venesection combined with intravenous infusion of isotonic salt solution, and found this to be very successful.

This last treatment has however not yet been tried out on human beings.

Oxygen should always be given to casualties with serious pulmonary oedema, that is, to cases of the "blue" or "grey" type. The need is continuous and over

a long period. It has been proved that no case in whom it was possible to restore a pink colour by the proper use of oxygen has died from simple pulmonary oedema.

In the early days of the War the administration of oxygen was faulty, but in August 1916 Major Adrian Stokes used an No. 8 catheter intranasally with great success. Later Professor J. S. Haldane (14) devised an apparatus in which there was much less wastage of oxygen, and which allowed of continuous administration at any required concentration over a long period. The oxygen does not require to be warmed whichever method is used.

Later a distributing apparatus was devised by which many men could be treated simultaneously by means of a central reservoir, which acted as a pressure reducing chamber, and from which rubber leads branched off to nozzles which could be taken to individual bedsides.

A description of the routine of oxygen administration is given in detail in Air Raid Precautions Handbook - Medical Treatment of Gas Casualties. (15) The routine suggested is twenty-five minutes on, and five minutes off, continued until the five minutes interval produces no clinical setback. When this stage is reached it is usual to find that no further oxygen is needed, and recovery is certain, unless there should be a relapse due to pneumonia.

Drugs are not of much assistance in the medical treatment of lung irritant casualties. Atrophine is discounted, and, as it may lead to acceleration of the

heart, is not used. Morphia should be restricted to severe cases with extreme restlessness, and not more than Gr. one sixth should ever be given.

Brandy has proved to be the most effective stimulant, but injections of camphor in oil, and caffeine have also proved of value. Digitalis and strychnine are not recommended. Phenacetin also should not be used even where headache is marked.

A mild expectorant mixture may be given after forty-eight hours, when acute symptoms have definitely begun to abate.

Expectoration may be assisted in certain cases by a suitable posture. The patient's head may be turned sideways and the foot of the bed or stretcher raised up to three feet for a few minutes at a time with the idea of draining fluid from the chest.

If broncho-pneumonia develops the patient must be treated in a separate ward, or separated by at least six feet from his nearest neighbour.

The diet should consist of fluids only in the acute stage and should be kept light until the patient is definitely convalescent. The bowels should be kept open and attention must be paid to the mouth which usually becomes dry and foul.

The question of evacuation of civilian casualties from lung irritant gas will be discussed at a later stage in this thesis.

CHAPTER V.NOSE IRRITANT GAS.

Mention has been made of three examples of nasal irritants, but as has been stated the most efficient is dephenylamino-chlorarsine, or D.M., and hence will be described in full as being the one most likely to be used.

D.M. is a derivative of arseniuretted hydrogen, and is a yellow crystalline solid, melting at 195 degrees Centigrade, and boiling at 410 degrees Centigrade. It is insoluble in water and difficult to dissolve in ordinary organic solvents. When heated or dispersed by an explosive it is vapourised without decomposition in the form of an almost invisible cloud of minute particles which remain suspended in the air. ("Particulate cloud").

The main feature of D.M. is its power of causing violent sensory irritation in extremely low concentrations. When a student at the Army Gas School, the writer was subjected to a low concentration of this chemical agent. The gas chamber was entered with the respirator at the "alert" position and first no ill effects were noticed. At the end of ten minutes he noticed some watering of the eyes and a tendency to sneeze. A few minutes later there was pain in the nose and the gums, and headache. At this stage the respirator was donned, but no relief from the symptoms was obtained. At the end of a further five minutes the writer felt he

had had enough and left the gas chamber. The pain in the gums, and the headache remained for fully an hour after exposure, and no further work was done in the School that afternoon. This experience is fairly typical of a mild dose of a particular cloud. After higher concentrations the symptoms include nausea and vomiting, acute pain in the accessory sinuses, a burning sensation in the throat, tightness and pain in the chest, pain in the eyes and lachrimation. Acute mental distress is very marked in severe cases, and would be most alarming if experienced by the uneducated civilian who had received a large volume of this chemical.

All the symptoms however, clear up rapidly in a few hours after removal from the poisoned atmosphere.

No one has ever died as a result of nose irritant poisoning, and thus the morbid anatomy and pathology have never been discussed.

The treatment in the majority of cases consists of a brief period of rest, and this is generally all that is required. In a few very severe cases pain may call for medical relief, when the inhalation of a little chloroform will be found of great assistance. Irritation of the nose and throat can be relieved by the use of a 5% solution of Sodium Bicarbonate for nasal irrigation and as a gargle.

Owing to its potency, in extremely dilute concentrations it is quite possible that this agent may be used

against civil populations despite its non-lethal action. Thousands of people would be affected by small quantities who, if not properly informed, will tend to panic. The hospitals would be crowded out with hundreds of patients, not really requiring hospital treatment, but who would be feeling toxic and miserable, each convinced that he or she was badly poisoned.

The service respirator gives full protection against particulate clouds, but owing to its delayed effect a person who feels the symptoms coming on after donning his mask may lose faith in its protective powers, discard it, and so lay himself open to the action of one or other of the lethal gases. This method was first employed by the Germans in the Great War when they liberated both D.M. and phosgene simultaneously over the Allied lines.

CHAPTER VI.

CHAPTER VI.TEAR GASES OR LACHRIMATORS.

The lachrimators possess an action which is essentially selective, and attacks the mucous membrane of the eye and the upper respiratory tract.

Of the three examples already mentioned, ethylchloroacetate or K.S.K. will be described as it is the most likely agent of this group to be used against a civilian population.

K.S.K. is a dark brown oily liquid with a smell resembling that of pear drops. Its high boiling - 180 degrees Centigrade, and its comparatively low vapour pressure make it a very persistent compound. K.S.K. is effective in extremely low concentrations and its action is immediate. It is not lethal, but in high concentrations has an irritant effect on the upper respiratory passages, causing a cough and a feeling of tightness in the chest.

Removal from the poisoned atmosphere brings speedy relief.

The morbid anatomy and pathology have never been investigated, as no deaths occurred during the Great War as a result of its action.

When attending a gas demonstration at Porton the writer had some experience of this compound. When walking down wind of a crater caused by a K.S.K. shell, the first sensation noticed was intense watering of the eyes, quickly followed by spasm which was so intense that the eyes could not be opened. A certain amount of

pain was experienced when the concentration was fairly high. On donning the respirator relief was immediate.

Experience has shown that even after very severe exposures all symptoms disappear within twenty-four hours.

If the eyes should be contaminated by the actual liquid from a stray or bursting bomb, irrigation with normal saline will clear up any inflammation which may ensue.

Used on a civilian population, uneducated in gas training, any type of lachrymator would cause great panic. A trained and disciplined community would however, immediately recognise the nature of the trouble, would don its respirators and the chief object of the attack would be frustrated.

CHAPTER VII.

Blister Gases or Vesicants:-

This group includes dichlorodiethylsulphide or mustard gas and chlorovinyldichlorarsine or Lewisite, both of which will be described in detail in this thesis.

Mustard ^{"H.S."} gas was used both by the Germans and the Allies during the Great War.

The pure state differs somewhat from the crude form used in shell and bomb fillings. As met with in practice, it is a heavy, dark coloured, oily liquid which gives off a vapour with a pronounced odour which has been likened to many things, including mustard, horseradish and garlic. The practical point is, once it is smelt it is never forgotten, and the individual will always recognise it. It freezes at 6 degrees

Centigrade. and boils at two hundred and seventeen degrees Centigrade. The high freezing point, and high boiling point, combined with its low vapour pressure make mustard the most persistent of known war gases.

Mustard is, relatively speaking, a very stable compound and it is not easily broken down. It is hydrolysed slowly by cold water, but breaks down rapidly in hot water or steam. Other methods of destroying mustard include weathering, evaporation and chlorination. Mustard, both in the form of vapour and liquid dissolves readily in most oils and fats, and is soluble in alcohol and petrol. It is only slightly soluble in water.

A special feature of mustard is its power of penetration, and, given time, the liquid will penetrate anything except glass or new steel. This property, combined with its very high persistence, greatly complicates the problem of how to deal with it.

Mustard gas is an extremely dangerous substance, both as a liquid and a vapour, but its action is essentially local. The vapour is selective to the extent of acting more strongly on the greasy or oily parts of the body, but any part of the body exposed to it is liable to suffer.

The action of mustard is not immediate, and this constitutes one of the gravest dangers of this gas, as its presence may not be suspected for some time by untrained individuals.

Signs and symptoms do not begin to appear until after a lapse of two or three hours, or even longer.

Both liquid and vapour mustard devitalise tissues brought in contact with them, and these are easily injured by rubbing or pressure, and are very prone to secondary infection. Healing from mustard injury is very slow, owing to damage done to blood vessels and lymphatics.

All persons are sensitive to mustard, but sensitivity varies greatly in the individual. Concentration which ^{may} affect one person will not distress his neighbour. Exposure to the gas will render the average individual more sensitive to a subsequent attack. The coloured races are said to be less prone to becoming casualties than white men.

The great persistency, the high freezing point, the unusual stability, the ready solubility in animal fat, the abnormal penetrative powers and the great toxicity of dichlorodiethylsulphide make it one of the most dangerous of all chemicals used in warfare. Mustard affords the greatest problem of all to the organiser of any scheme put forward in the defence of an urban population.

Mustard gas acts on the following organs in order of frequency, eyes, lungs, skin, stomach and intestines. In all cases it produces intense inflammation, the morbid anatomy of which is discussed in detail.

The eyes are usually the first to show signs of irritant mustard gas vapour, even so the onset of injury may be delayed, the latent period varying from two to forty-eight hours. The initial symptoms of smarting and irritation are soon followed by lachrymation, pain in the eyes and headache. Swelling of the eyelids follows and the palpebral fissure may even be completely closed. Later the simple lachrymation becomes muco-purulent and blepharospasm and photophobia are marked.

Later the eyeball is affected, injection being followed by swelling and oedema to such an extent that the conjunctiva at the interpalpebral aperture may project between the eyelids, and form a characteristic opaque band on either side of the cornea. A similar swelling of the palpebral conjunctiva under the eyelids, may produce two chemotic folds which project between the eyelids.

In the early stages the cornea is grey and hazy. Its surface becomes blurred and lustreless. Exfoliation of the corneal cells may occur, and ulceration may follow which, if complicated by secondary infection, may lead to permanent opacities.

Recovery is very slow. The oedema gradually subsides and the corneal epithelium begins to regain its lustre. The interpalpebral area, previously dead white, goes through a period of injection, whilst the previously injected areas protected by the eyelids, are

regaining their normal tint. In the absence of ulceration or adhesions no permanent after-effects are usually met, but neurasthenic conditions may supervene in susceptible individuals. Only a few of the very severe cases with corneal changes sustain any impairment of vision.

The pathological lesions in the Human Eye, consist of varying degrees of conjunctivitis in all stages from mild simple, to chronic proliferative. The lesion is most marked in the palpebral fissure. Mild cases soon recover, but the severe cases develop hyperaemia, new blood vessels form and later, scar tissue. In chronic cases there may be ultimate pigmentation of the conjunctiva.

Warthin and Weller (16) have described a series of experiments carried out on rabbits. A standard solution of weak mustard liquid was dropped into the eye of each animal, and the results examined at varying intervals.

The main conclusion drawn from their experiments, was that the seropurulent discharge which formed must be removed from the eye at frequent intervals, and that pressure in all forms must be avoided.

The toxic effects of mustard gas vapour on the respiratory tract are shown by an early rhinitis which coincides with the onset of the conjunctivitis. The rhinitis is accompanied by sneezing and the discharge of

a profuse watery secretion which later becomes mucopurulent. Laryngitis may set in in a mild case, but oedema and even sloughing of the vocal cords may follow exposure to a high concentration. In the severe cases the trachea and bronchi are also affected, and a loose cough, accompanied by profuse mucopurulent expectoration is complained of. A rising temperature and pulse indicate the onset of severe bronchitis, which may be complicated by the sloughing of the inflamed trachea mucous membrane. A later development is broncho-pneumonia with cyanosis, if secondary infection sets in. In the great majority of cases however, the lesion is confined to a bronchitis which clears up in the course of six weeks, leaving no after-effects.

A description of the post-mortem findings in mustard gas poisoning is given in the Official History of the Great War. (17).

On examination of the respiratory tract there was intense inflammation from the anterior nares to the ends of the bronchial tubes. In some cases destruction of membrane was so great that the whole area of the trachea and larger bronchi was covered by a loosely adherent false membrane, or a yellow slough. On removing this slough, a raw granulating surface with numbers of small ulcers was left.

The lungs were voluminous, and completely filled the thoracic cavity. Small petechial haemorrhages were observed on the pleural surface.

When sectioned the lung was found to be dry.

In later cases with secondary infection pus is secreted which gravitates downwards and sets up broncho-pneumonia. Later still the whole of the lower lobe may be solid from the confluence of numerous patches of broncho-pneumonia, which again may break down and form abscesses.

Winternitz (18) and others have described a series of experiments showing the effect of mustard gas on the respiratory system of dogs. The results are summarised briefly in three groups as follows :-

In the first group, animals which died in the acute stages after exposure showed marked congestion of the lungs with little oedema. Atelectasis was present in some lobes or parts of lobes. There was great destruction of the upper respiratory passages with false membrane formation and signs of commencing bacterial invasion. Necrosis of the walls of the bronchioles, as well as the surrounding alveoli, occurred; and haemorrhage noted in the vicinity.

The next group included dogs which died from two to ten days after exposure and all showed signs of extensive broncho-pneumonia.

The final group were those dogs which recovered from acute poisoning. The chronic lesions included ulceration or constriction of the trachea, superficial ulceration of the buccal mucous membrane and minute areas of organisation of the lungs.

From the above descriptions it is seen that the essential fatal lesion of mustard gas poisoning is a broncho-pneumonia, caused by secondary infection, setting in on top of the bronchitis caused by the irritant action of the gas.

The skin exhibits all stages of burn from primary erythema up to the final stage of a deep burn with necrosis, after contact with liquid or vapour mustard.

A mustard burn differs from a thermal burn in the following respects:-

- a. Slow and progressive development of the lesion.
- b. A more intense inflammatory reaction.
- c. Marked delay in the process of repair.
- d. Greater tendency to septic infection.

Warthin and Weller (19) have described in detail the changes which take place in the skin following contact with mustard. Briefly their conclusions were as follows :-

Mustard gas is an escharotic, specific in its action on the epidermis and tissues of the corium, particularly on the endothelium of the vessels.

The lesion is a chemical burn with a high degree of fluid exudation, great moistness of the affected area and a degree of necrosis which requires hours or even days for its complete development. The vessels in the affected area are severely damaged and collapsed, and there is local anaemia in the earlier stages with marked fluid exudation and leucocyte migration. The process is non-haemorrhagic, and non-thrombosing. In man the necrosis of the epidermis is

usually evident in two hours. There is no deep oedema in man, but in animals it is intense and altogether different. Vesicle formation is evident in man, but not in animals. The deep penetration of even the smallest quantities applied to the surface is a striking feature. There is undoubted entrance through the hair follicles, sebaceous and sweat glands. The slow progressive character of the necrosis reaches a height from five to ten days after application. The painlessness of the lesion is also a marked characteristic. This may be explained by degeneration of the nerve endings of the affected portions.

The above description gives some explanation of the difficulties experienced when considering the treatment of these lesions.

The stomach and intestines are only affected when mustard contaminated food has been eaten or when nasal secretion has been swallowed. There may be some vomiting following congestion of the stomach, but generally speaking there are no lasting after effects. Haematemesis is exceedingly rare.

The liver and spleen seldom show any changes.

The kidneys are affected in a small proportion of cases. Acute haemorrhagic nephritis is very rare, but congestive changes in the glomeruli and desquamation of the tubules have been found in fatal cases. Albuminuria has been described in the first twenty-four hours, but is not found at a later date.



The brain seldom shows any change, but small haemorrhages have been reported in late cases.

From the above description of the morbid anatomy of mustard gas poisoning it will be seen that the effects of the gas are wide-spread. All authorities are agreed however, that the gas itself, is not absorbed into the system.

The treatment of mustard gas poisoning is discussed under two headings.

- a. Preventive.
- b. Curative.

The preventive measures taken include early detection of the gas by its odour or by means of chemically prepared paper, early and proper adjustment of the respirator, which affords complete protection to the eyes and the respiratory system, and the wearing of protective clothing.

Time is the factor of paramount importance in preventive treatment, which consists essentially in the complete removal of the clothes of the contaminated person, and in cleansing the skin. It is stated in the United States Army Version of the History of the War (20) that the amount of mustard vapour passing into the atmosphere from an exposed surface of skin far exceeds the amount passing inwards to the deeper strata of the skin. It is also stated in the same article that "while a portion of the mustard passes through

immediately to a point from where it cannot be removed, the greater part remains on, or near the surface, where it can be removed fifteen minutes after by use of solvents."

British authorities lay down that in order to avoid injury liquid mustard must be completely removed from the skin within four minutes. If however, the individual has been subjected to a concentration of vapour only, a longer period of contact is required to produce injury.

Cleansing of the skin may be carried out either by a process of mechanical removal, or by chemical destruction by means of bleach. Mechanical removal is best carried out by means of scrubbing, preferably in a bath with soap and water, using frequent changes of water, and taking not less than five minutes over the operation.

Chemical destruction may be employed by rubbing well into the affected area a bleach preparation either in the form of a cream or an ointment, or an aqueous bleach paste. The bleach should be left undisturbed for a few minutes before ^{being} washed off.

If erythema has already developed bleach must not be used in any form as it aggravates the condition.

Bleach ointment is made by mixing equal parts by weight of supertropical bleach and white mineral jelly, while the aqueous bleach paste consists of supertropical bleach mixed to a creamy consistency with water. Roughly one part of bleach to one or two parts of water.

Liquid mustard gas can also be removed from the skin by means of solvents such as petrol, kerosene, carbon tetrachloride, tincture of green soft soap, but it is important to remember that these do not destroy the gas, but merely dissolve it. Hence the swabbing must be confined strictly to the contaminated area. Certain precautions are necessary. Oil skin or rubber gloves must be used or the clothes held by forceps, and the contaminated swabs must be removed and destroyed. Treatment by these solvents must be followed by further washing of the whole body with soap and water.

Where contamination is by vapour only, removal of the clothes and a hot bath will suffice.

The eyes require special treatment as bleach cannot be used. Contamination of the eye by liquid mustard indicates thorough flushing out of the conjunctival sac with plain warm water after opening the eyelids wide. This flushing must be repeated every hour. If evidence of local irritation appears a drop of liquid paraffin could be instilled.

The curative treatment of mustard gas casualties is described under three headings:-

- a. Treatment of the eyes.
- b. Treatment of the respiratory tract.
- c. Treatment of the skin.

The Home Office Handbook (21) on the Medical Treatment of Gas Casualties suggests frequent lavage

with a warm 2% solution of boric acid or normal saline solution. After the onset of clinical signs, if spasm and pain are marked, the application of a sterilised 1% atropine ointment is recommended, and reapplied every twelve hours until relief is given. Cocaine is contraindicated, as it tends to loosen the corneal-epithelium and to facilitate ulceration. Free drainage of the discharge is essential and on no account should the eye be bandaged as this will only dam back the secretion with disastrous results. Shades of brown paper may be used to relieve photophobia, and a few drops of sterilised liquid paraffin may be inserted several times a day to prevent the eyelids becoming glued together. When the discharge becomes mucopurulent 2% solution of Argylol or Protargol may be used twice daily. Should ulceration occur the ulcer may be cautiously cauterised by the light application of pure carbolic acid put on with nearly dry brush slightly moistened with the liquid. Occasional bathing and hot applications over closed lids four times a day will assist in relieving pain. If hypopyon supervenes and does not clear up with hot bathing, atrophine and frequent cleansing of the conjunctival sac, Saemisch section is indicated.

When there is only vapour contamination of the eye, the prognosis is much more favourable, and the patient must be reassured from the onset that his eyesight will not be lost. For mild cases frequent lavage and installation of paraffin is all that is required. In more severe cases treatment should be on the lines of

that recommended for cases of liquid contamination

Warthin and Weller (22) do not agree with the use of the silver preparations, as they consider that they cause destruction of the cornea. These authors recommend irrigation with a .5 or one per cent solution of dichloramine T. in chlorcosane both as a preventive measure. Warthin states that if it is instilled before exposure to mustard no lesion will take place. It is suggested by these American writers that irrigation with this solution should be started early, and continued right through the first few days, being repeated every two hours. Dichloramine T. in chorcosane has a germicidal action as well as a specific action on mustard. Each irrigation should be followed by frequent lavage with saturated solution of boracic acid. Both authorities are unanimous in condemning the use of bandages, compresses or cocaine.

In treatment of the respiratory tract, douches of 5% solution of sodium bicarbonate will relieve the early rhinitis. Solution of zinc sulphate and boracic acid will be found helpful if the nasal discharge becomes mucopurulent. Laryngeal irritation is dealt with by the inhalation of steam from a pint of boiling water containing a teaspoonful of a mixture of methol Gr. 10 to 1 ounce of Tinct. Benzoin Co.

Treatment should be directed from the onset towards combatting bacterial invasion of the bronchi. All cases of mustard poisoning in which the respiratory tract is involved must be kept apart from other patients

suffering from infective pulmonary disorder. They should if possible be segregated in special wards, and the onset of broncho-pneumonia in one of them should entail isolation.

Vadder (23) recommends the routine inhalation of volatile antiseptics from a pliable perforated mask, fashioned in the form of a Burney Yeo Inhaler, containing a pad of gauze on which a few drops of the antiseptic are placed every hour. Vadder suggests the following formula :-

| | | | |
|------------------|-----|--------|-------|
| Menthol | 2.5 | grams. | |
| Chloroform | 8 | ccs. | 9 |
| Ol.Eucalypt. | 8 | ccs. | 9 |
| Creosote | 8 | ccs. | 9 |
| Tr. Iodine | 4 | ccs. | 4 1/2 |
| Sp.Vini Rect. ad | 60 | ccs. | 6 1/2 |

15 drops on a cotton mask every hour.

The value of menthol in mustard gassing is enhanced in those cases which require operative treatment for some concomitant wound. In these cases until the larynx has been treated with menthol there is so much spasm that an anaesthetic cannot be given.

The treatment of broncho-pneumonia follows the recognised rules of procedure, including the employment of expectorants where the muco-pus is tenacious. Venesection has no place in the treatment of mustard gas casualties, except on rare occasions when there is right heart embarrassment induced by a diffuse broncho-pneumonia. Sililarly oxygen has a very limited use in these cases, except when a condition of oxygen want is

established as a result of grave and widespread pulmonary damage.

When considering treatment of the skin, septic infection is as in other regions of the body, the most potent factor in delaying the satisfactory healing of skin burns. Similarly it is obvious that early preventive treatment is of paramount importance. As a preliminary to all local treatment it is essential to cleanse the skin as thoroughly as possible and to clip short all hair in, or near, the affected area.

In The U.S. History of the Great War (24) it is stated that statistics definitely prove that long hair harboured mustard gas, and gave rise to a much more serious injury than might have otherwise been the case. The author also states that in the majority of severe skin burns of the face and neck the patient had long hair.

Skin surfaces damaged by mustard gas are exceedingly susceptible to trauma and the continued presence of an ill-fitting bandage will lead to an extension of the damage.

Treatment varies according to the nature and degree of the burns, and mild cases which have not proceeded beyond the erythematous stage heal spontaneously with possibly a little desquamation. If the skin is unbroken a mild dusting powder may be applied and Anaesthesin, which is the ethyl ester of p-amido-benzoic acid, is recommended to allay the irritation.

More severe cases in which there is vesication

are a much more difficult problem. Any available cleansing treatment in use in surgical practice will suffice for the undamaged skin surrounding the burn itself. In the last War extensive use was made of Dakins solution for the treatment of burns, but in A.R.P. Handbook No. 3 (Medical Treatment of Gas Casualties) it is described as being too painful for continued use on raw surfaces. Warthin and Weller (26) however, recommend the use of Dakins solution, and also dichloramine T. in chlorcosane either by the immersion of the patient, on dressings, or by irrigation of the skin surface. They also recommend compresses of hypertonic saline, and suggest the following routine. During the day Dakin or dichloramine T. treatment for one hour, hypertonic saline for two hours, and ordinary saline for one hour in rotation. At night the skin should be dried and a vanishing cream containing 1% dichloramine T. should be applied.

Warthin does not favour Vincents or other dusting powder, and condemns the use of magnesium sulphate, potassium permanganate or silver nitrate. He agrees with the British authorities that ^evesicles should be emptied with a needle and syringe under aseptic conditions. The vesicle is allowed to collapse and treatment is continued as above. If open sores are present the Americans recommend the use of a bath made up as follows:- one pound of commercial corn starch and one pound of sodium bicarbonate are added to twenty gallons of sterile physiological salt solution at 90° F. The patient

is allowed to remain in the bath any period from fifteen minutes to forty eight hours. If necessary he may be suspended in the bath in a cradle. If the pulse weakens the patient must be removed or given strychnine or digitalis.

If sloughs occur, necrotic tissue is removed with sterile forceps, or by frequent hot irrigations under pressure, or boracic or hypochlorite solution.

In very severe cases Carrells hypochlorite solution may be used, either as a bath or by tepid sponging. This solution is made by adding 12.5 grams of bleach to 1 litre of water. The mixture is well shaken and 12.5 grams of powdered borac acid are added, and the whole shaken again. The solution is filtered after being allowed to stand for twelve hours, and is then ready for use.

The Home Office suggest that after evacuating blisters, dry dressings should be applied. When larger areas are affected and when the blisters are confluent the use of a non-irritating antiseptic such as Dettol, combined with a freshly prepared 5% solution of Tannic acid is recommended. After evacuating all blisters and removing the loose epithelium the solution is applied directly to the raw surfaces either as a spray or on lint. Coagulum forms and cotton wool and bandage are lightly applied over this. The lint is left in position and resoaked every three or four hours until, at the end of twelve hours, when the entire dressing is removed, a

firm coagulum has formed; this is then sprayed with 5% Tannic acid solution and dried. This treatment is recommended by Mitchener (27) who also recommends preliminary swabbing of a large area surrounding the burn with antiseptics.

After the separation of the coagulum general principles of wound treatment are applied to the unhealed areas which may remain. Stimulating lotions will be found of use in encouraging the growth of new epithelium. Where the genitalia or groins are affected, hot hip baths of isotonic salt solution are helpful in allaying the intense irritation.

Ointments and pastes are contra-indicated because of their tendency to seal up the discharges. Similarly powders are undesirable where the skin is broken as they form crusts which retain the discharge. Oiled silk should never be used on compresses.

Epigastric pain is relieved by the administration of sodium bicarbonate by mouth. This treatment also helps all cases in which the kidneys are affected. Where there is severe kidney trouble a low protein and salt free diet is recommended, and in very severe cases a Murphy drip will be of great assistance.

In all cases of mustard gas poisoning the patient should be encouraged to drink as much water as possible.

As convalescence proceeds a full diet is required. Functional disorders are frequent sequelae to mustard poisoning, and require treatment of a specialist nature.

CHAPTER VIII.

Lewisite or chlorovinyldichlorarsine is an important chemical compound developed towards the end of the War, so that knowledge of its action rests on laboratory experience rather than on the study of actual war casualties.

In the pure state Lewisite is a powerfully toxic substance, embodying the aggressive qualities of the asphyxiant gases, the irritant characteristics of the tear and nasal irritant gases, and the universal action on all contaminated tissues of the blister gases. Under modern conditions of chemical warfare its vesicant action would predominate.

The effects of Lewisite on the human body are similar to those produced by mustard gas, but it is more easily detected as it has an immediate irritant action both on the respiratory tract and on the skin. It is assumed that, as in the case of mustard gas, Lewisite could be used either in bombs or as a spray.

Lewisite is a heavy, oily liquid, the impure form of which is more likely to be used in war. It is extremely irritating to the nose, giving rise to sneezing and lachrimation. On contact with moisture or in the impure form, it possesses an odour like that of geraniums.

Lewisite boils at 190° C. and is therefore classed as being highly persistent. Unlike mustard gas it has a low freezing point, i.e. -13° C.

Lewisite is insoluble in water, but is easily hydrolysed, with the production of hydro-chloric acid and organic oxides. It is readily decomposed by alkalis, and is freely soluble in the ordinary organic solvents in the petroleum series, and in oil and fats. Lewisite is much less stable than mustard, although in the absence of hydrolysis it retains its vesicant properties for a considerable time. As with mustard gas, strong oxidising agents or chlorine will neutralise Lewisite, though not so readily.

Like mustard gas Lewisite possesses powerful penetrative properties which enable it to render clothing dangerous to wear or handle.

Under suitable conditions it may produce vesication of the skin in the vapour state. In the Liquid form it penetrates the tissues rapidly, and after a short latent period gives rise to severe blistering.

Liquid Lewisite in the eye entails immediate incapacitation.

A summary of the comparative properties of mustard and Lewisite is given in the United States History of the Great War (28).Lewisite

- a. Causes earlier necrosis of the epidermis.
- b. Causes more extensive oedema, with a definitely fibrinous exudate.
- c. Causes earlier appearance of inflammation.
- d. Causes more frequent appearance of vascular thrombosis.
- e. Does not penetrate hair follicles.
- f. Recuperative changes commence after forty-eight hours, as opposed to a minimum period of seven days with mustard.

The rapid adjustment of the respirator affords security against serious respiratory lesions and eye complications. In the absence of such protection the train of symptoms is much more acute than with mustard gas. Even in low concentrations the naso-pharynx is affected within a few minutes and laryngeal irritation quickly supervenes. Generalised bronchitis is well established within twenty-four hours, which, in a severe case, may lead to broncho-pneumonia and death.

Wet clothing is a partial safeguard as far as the skin is concerned, but dry clothing absorbs Lewisite vapour, and is rendered dangerous for continued wear.

The action of Lewisite vapour does not generally go beyond causing an erythematous condition of the area affected. In high concentrations or after long exposure, vesication may occur, when the skin presents an angry surface interspersed with small, shallow, turbid blisters, which may coalesce to form one large vesicle. There is more irritation than with the corresponding mustard gas vapour burn.

Liquid Lewisite attacks the bare skin on contact and penetration is very rapid. The application is followed immediately by a stinging sensation, which may prove severe if a very sensitive surface be affected.

Within half an hour of contamination with liquid Lewisite erythema of the skin develops rapidly. Vesication is fully developed within twelve hours or less. The Lewisite blister is sharply defined, and overlies practically the whole of the erythematous area, and is

filled with an opaque or opalescent fluid which, on examination, is found to be rich in leucocytes, and contains traces of arsenic.

Healing of small localised Lewisite blisters readily takes place in the absence of secondary infection, but if sepsis be present the condition requires a long time to clear up.

The risk of serious arsenical poisoning has not yet been studied on the human subject, but the danger appears to be remote.

The dangerous possibilities of aircraft spray in connection with eye contamination by liquid Lewisite must be considered. However small the contamination the impact of the liquid on the conjunctiva causes immediate pain, spasm and lachrimation, and the victim becomes an immediate casualty. Acute inflammation of the conjunctiva with engorgement of the blood vessels is well established in fifteen minutes; and within three or four hours the clinical picture is alarming. There is intense oedema, closed eyelids, the separation of which releases purulent fluid, chemosis, submucous haemorrhages and extensive ulceration of the conjunctiva. The cornea is hazy and generally the condition is more distressing than that produced by liquid mustard gas in twenty-four hours.

The prognosis in liquid Lewisite contamination of the eye is even more serious than with liquid mustard gas.

The preventive treatment in the case of Lewisite contamination consists in the speedy removal of all

clothing followed by a hot bath, combined with the liberal use of soap. Irrigation of the eyes and nasopharynx with solution of sodium bicarbonate may help to ward off serious effects.

The curative treatment of Lewisite lesions is mainly symptomatic and follows the same lines as the treatment of mustard gas casualties. If vesication occurs it is essential that the fluid be evacuated early, the epithelium removed and the raw surface irrigated in order to lessen the danger of absorption of arsenic.

Before leaving the problem of the vesicant gases it should be pointed out that the service, or other respirator only protects the eyes, respiratory passages and skin of the face against the action of mustard and Lewisite. When it is essential that a man will have to work in an atmosphere of vesicant gas he will require protection of the remaining areas of the skin. Since the Great War many experiments have been carried out, and a form of protective clothing has been devised. It consists of a uniform made from navy oil-skin, combined with knee-high rubber boots. The oilskin and the rubber are comparatively resistant to both mustard and Lewisite, and will keep out either, even in the liquid state, for several hours.

There are two grades of protective clothing, full or complete, and light, and these will be described later in the thesis.

It should be noted that in the later part of the thesis the terms "contaminated" and "decontamination" will occur frequently. When mentioned with no qualification it is understood that they are being referred to in connection with the mustard Lewisite group of gases.

their employees and passengers. Several of the larger commercial firms and manufacturers in the City have prepared complete schemes for the safeguarding of their own employees. For example The British United Shoe Machinery Company with a pay-roll of over 7,000, is building its own first aid post, and has organised its own first aid parties.

The Medical Services:- The organisation of the medical services is under the Medical Officer of Health with the Deputy Medical Officer of Health in charge of Air Raid Precautions, as his assistant. The local commandant of the St John Ambulance Brigade is responsible under the Medical Officer of Health for the personell of first aid parties and first aid posts. The Ambulance Transport Officer is responsible for ambulance services, the head of each hospital for hospital services and the Chief Sanitary Inspector for laundry services, each being subject to the general supervision of the Medical Officer of Health.

Decontamination services are directed by the superintendent of decontamination, who is under the control of the chief official of the Street Cleansing Department.

An Air Raid Precautions organiser, or co-ordination officer has been appointed to insure co-operation among the different departments. He however, does not relieve the heads of the technical departments of responsibility for technical aspects of Air Raid Precautions. An outline of the Medical side of the scheme is shown in Appendix A.

Wing Commander E. J. Hodsall, Assistant Under Secretary of State in charge of the Air Raid Precautions Department of the Home Office, in an address, has made it quite clear that at this stage all that is asked of local authorities is to ascertain how certain of their existing organisations could be adapted, in time of emergency, to carry out particular work which would be required to help, save and preserve life, and to keep essential services in operation. He goes on to state that the expense of respirators and protective clothing required for personnel will be borne by the Government, and that necessary stocks of bleach powder will be accumulated and distributed also. He also asks that expenditure for the moment should be confined to the training of personnel in their special duties.

The whole of the Home Office proposals have been most carefully considered and they have been framed with the idea of reducing any expenditure which might fall on local authorities to an absolute minimum.

The Government have promised that eventually they will afford such financial assistance as may be necessary to meet with the potential emergency requirements of such stores and equipment as will be required for hospitals, first aid posts etc.

The /

The Preparation of a Scheme for the Organisation of Air
Raid Casualty Services in an Urban District.

The Air Raid Precautions Department of the Home Office (29) have laid down an outline of the organisation required in a County Borough. This should include :-

1. First aid parties available to be despatched to any place where air raid casualties occurred.
2. First aid posts to which persons with comparatively minor injuries or suffering slightly from gas, or with contaminated clothing could walk or be carried for treatment, and if necessary, a change of clothing.
3. "Casualty clearing hospitals" to which more serious cases could be taken by ambulance, and, if not fit for immediate transfer to Base hospital, detained and treated.
4. "Base hospitals", situated as far as possible outside areas of special danger, for cases evacuated from casualty clearing hospitals.
5. An ambulance service for use in conjunction with first aid parties, and for the movement of stretcher cases from first aid posts to casualty clearing hospitals, and from casualty clearing hospitals to base hospitals.
6. Laundry etc. services for the decontamination of contaminated clothing.
7. A clerical organisation for keeping records of casualties, their property and valuables, and their places of treatment.

These headings are given by the Home Office with the purpose of assisting local authorities in the formation of a scheme. It is agreed however, that local conditions in every case will modify such a scheme, and the details are left entirely in the hands of local officials.

At present the chief difficulty is one of finance. The municipal authorities and the Government cannot agree as to the percentage of the cost which will be borne by each. In the meantime schemes have to be prepared, and costs estimated without the actual expenditure of large sums of money.

It is desirable in the first place to distinguish three main classes of patients who might require attention.

- a. Persons who are suffering from physical injury or who have inhaled gas, but are not affected or contaminated with persistent gas.
- b. Persons suffering from such physical injuries who are also contaminated with persistent gas.
- c. Uninjured persons, whose skin or clothing has been contaminated with persistent gas.

It is recommended that all these classes should be dealt with by a single organisation which would combine the normal type of ambulance and hospital service for the treatment of accidents with special arrangements for dealing with gas contamination of persons and their clothing.

It is impossible to forecast the number of casualties which might have to be treated in any district, and it is therefore suggested that the provision for dealing with casualties and contaminated persons should be governed primarily by considerations of situation. In urban areas First Aid Parties and First Aid Posts should be provided at frequent intervals so that the parties could quickly reach any scene of damage and no casualty would have to walk far to reach a Post.

The scale of hospital accommodation and equipment required will vary considerable with locality; the number of beds required to be set aside for Air Raid Precautions purposes has been communicated to all local authorities.

It is not intended that any area within which a complete scheme is prepared should necessarily be limited to its own area as regards arrangements for hospital accommodation.

During the combined manoeuvres which were conducted in the vicinity of Southampton this summer, a practice Air Raid Precautions scheme was tried out by the civil authorities. All lights were blotted out and the civil population co-operated magnificently in assisting the authorities to make the practice a success. Trials were carried out on dummy casualties and our official observer was able to give the writer several hints as to difficulties experienced.

Full protective clothing was worn by personnel and conditions were made as "life-like" as possible. Formations of bombers "attacked" the city, search lights were played on them, and for the purpose of our scheme imaginary bombs of different types were "dropped" in various parts of the city.

CHAPTER X.FIRST AID PARTIES.

The object of first aid parties is to provide first aid, to give assistance to casualties on the spot, and if necessary convey them to the nearest first aid post or casualty clearing hospital.

First aid parties will be composed of four men and will be equipped as indicated in Appendix B. They will be provided with service respirators and full protective clothing, in addition to their stretchers and first aid equipment.

For a city such as Leicester the Home Office recommends that twelve to fifteen parties should be formed for every hundred thousand population, which means that we should require from thirty to forty parties for our scheme.

During the Southampton manoeuvres already mentioned the time taken by first aid parties to arrive at the scene of action was considered to be too long. In one case it was forty-five minutes before assistance reached a "severe injury" resulting from a high explosive bomb. This time factor was apparently caused by a shortage of first aid parties, their lack of suitable distribution, and the difficulty experienced by transport vehicles making their way through the streets in pitch darkness.

As a result of these operations we have decided to increase our number of First Aid parties to eighty-six. These will be distributed over thirty-two de-

pots in sites which have been selected in all parts of the city. Two parties will be posted to each depot and twelve squads are to be kept in reserve at the central stations. Each depot will have one auxiliary motor ambulance vehicle attached to it.

A centralised plan in which all first aid parties were kept at a central station and sent out on the order of an officer in charge was tried out in the Southampton scheme. This was however, not successful, and is one of the reasons why the Leicester scheme for first aid parties is based on de-centralisation.

Such communication will be made direct to the depot by telephone if possible. The warden will also inform headquarters direct.

If additional first aid parties are required, these will be ordered to the scene of action by headquarters.

An expert from the Gas Detection Service, if available, will be sent to the scene, who will decide whether or not the area requires decontamination.

The depots will be distributed throughout the City as follows:

1. Payne Street Yard.
2. Overton Road School.
3. The Langhill School.
4. West Humberstone Destructor.
5. Tram Depot London Road Terminus.
6. Knighton Road School.
7. Ingle Street Yard.
8. Old Police Station Landsdowne Road.
9. Avenue Road Extension School.
10. Electricity Department Bradbourne Road.

11. Medway Street School.
12. Green Lane Road School.
13. Nedham Street Destructor.
14. Sawday Street School.
15. Lighting Department Rutland Street.
16. Town Hall.
17. Mill Lane Destructor.
18. Ellesmere Road School.
19. Hamelyn Road School.
20. Hinckley Road School.
21. Narborough Road School.
22. Shaftesbury Road School.
23. Noble Street School.
24. Willow Street School.
25. Martin Street School.
26. Grape Street Depot.
27. Jarvis Street Depot.
28. Slater Street Depot.
29. Friday Street Depot.
30. Tudor Road School.
31. Abbey Park Road Depot.
32. Ellis Avenue School.

These sites have been chosen with due consideration to the relative population of the different areas and are all shown on the Map (Appendix C.).

It is hoped to obtain the entire personnel for first aid parties from the St. John Ambulance Brigade.

All St. John personnel will be fully trained in first aid work and anti-gas precautions. It is intended that personnel from first aid parties should be inter-changeable with that of first aid posts. In several instances it will be seen from our map, Appendix C., that the first aid party depots are contained in the same block of buildings as a first aid post. This is unavoidable owing to the difficulties experienced in selecting sites for these activities. In cases where there is a combined depot and first aid

post in one block of buildings, the aid post cleansing room could be used by the staff of the first aid and rescue parties.

A completed first aid party depot is being constructed at the Jarvis Street Cleansing Station and will soon be ready for use. This site is number 27 on the map, and a complete plan of the decontamination and undressing rooms for personnel is given in Appendix D. This depot is being built for training purposes, and is similar to the one in existence at the Falfield Antigas School. It will be very useful, as all personnel will receive a thorough training, and will have a good idea of the processes employed during the undressing and decontamination of personnel.

Full "protective clothing" is required by the personnel of first aid parties with the exception of the reserve. The "complete" outfit consists of the following:-

- Oil-skin jacket.
- Oil-skin trousers.
- Oil-skin hood.
- Oil-skin gloves.
- Rubber gum boots to the knee.
- General service respirator.

The non-porous nature of the special oil skin material used causes the heat and perspiration of the body to be retained inside the clothing. The amount of manual work that a person wearing oil-skin can accomplish is consequently limited owing to fatigue and exhaustion. Protective suits therefore should not be employed unless the circumstances make it essential.

The hood in particular is only worn when work has to be performed in a confined space which contains mustard gas vapour.

In temperate climates a fit man can do two spells of hard work of two hours each during the day, if an interval of four hours rest is allowed between the spells of work. In cold or wet weather the working time can be considerably extended. After each spell of work in a mustard area, the protective clothing must be removed by another man, (himself suitably protected) and the wearer must have a bath, followed by a change into fresh underclothing. It is for this reason that special undressing rooms are required. If contaminated with gas the protective suit will require to be decontaminated before it can be worn again, and the underclothing will require a thorough washing.

In view of the extreme fatigue caused by work when this outfit is worn, the carrying of stretchers must be reduced to an absolute minimum. The auxiliary motor vehicle attached to each depot will convey the men as close to the scene of action as possible, and will be ready to convey serious stretcher cases direct to the casualty clearing hospitals. The driver of such a vehicle will be trained in first aid and anti-gas measures and will be provided with "light" protective clothing.

Light protective clothing consists of:
 Oil-skin gloves.
 Oil-skin smock.
 Rubber gum boots.
 Special service respirator.

It is our intention that the 20% reserve of first aid parties should be equipped with light protective clothing and not full protective clothing. Our idea is that should any special area be so heavily bombed that motor vehicles are unable to proceed along the streets, these parties will be more suitably dressed for long stretcher carries. They would be rushed as near as possible by lorry, and would take over stretcher cases from their more fully protected colleagues near the heavily contaminated area.

During the Southampton manoeuvres a practical difficulty arose in the matter of the equipment supplied to first aid parties. Three different types were tried out: (a) St. John Ambulance Brigade Pattern; (b) Standard Air Raid Precautions Memo No.1 Pattern; (c) Modified Air Raid Precautions Memo No.1 Pattern. There was little to choose between them, but it was found that in the dark it was difficult to get the equipment from the tightly packed pouch or haversack in each case. In addition packages felt much alike, bottles were the same shape, and difficulty was experienced in identifying particular requirements by touch.

The writer has discussed this matter with the managing director of a large firm of surgical equipment manufacturers, and a modified set of equipment is being evolved. Experiments have not quite been com-

pleted, but we hope to be able to bring forward a first aid pouch and surgical haversack which will provide easy access and the contents of which can be identified in the dark by touch.

The question of using special casualty labels by first aid parties has been much discussed. During the Southampton manoeuvres they were used somewhat irregularly, no doubt owing to want of training and lack of light. The few received proved their possibility and efficiency. It is intended that first aid parties will use these labels when our scheme is put into operation, as we consider they will help very much when the patient arrives at the casualty clearing hospital.

"Rescue" parties have been organised under the City Engineer's Department consisting of trained Corporation employees who will be provided with full protective clothing and their own equipment, and whose object is to rescue wounded persons from the debris of fallen buildings, to shore up partially destroyed houses and to complete demolishments where necessary. One of these rescue parties will be posted to each first aid depot and will work in conjunction with the first aid party. These rescue parties are all trained in decontamination work in addition to their ordinary training.

For administrative purposes the thirty-two depots have been divided into four groups. Each

group will have its central depot, and will be under the control of an officer who will have one or more assistants. The dressing, undressing, cleansing and decontamination of both first aid and rescue parties will be carried out at these central depots. Quarters will be provided for reliefs, and arrangements made for meals etc. Each of these four central depots will be provided with full facilities for personnel to wash themselves, and the accommodation will be on the lines as described in A.R.P. Handbook No. 1.

In the instructions issued by the Home Office, cleansing and decontamination arrangements are required to be provided at each and every depot; but as there is a large increase on the estimated numbers, it is felt that it is better and more economical to provide first class accommodation at four depots rather than an inferior quality at the many.

All first aid party depots are to be provided (if not already installed) with a telephone to facilitate communication. If however, the telephone service is damaged an emergency messenger service which has been organised under the Chief Constable would come into operation.

An air raid warden service and a "gas detector" service have each been organised by the Watch Committee and come under the Police. Air raid wardens have been appointed for every small area in the city and one of their duties is to notify the nearest first aid party as soon as a bomb is dropped in their individual area.

CHAPTER XI.FIRST AID POSTS.

The plans for our organisation must be based on the assumption that there will be casualties resulting from the use of high explosives and that there may also be gas casualties. In planning the arrangement of first aid centres therefore, a large measure of elasticity is essential to insure that they are suitable for whatever conditions may arise. Persons who have been injured by splinters or by falling masonry may also be contaminated with persistent gas, and will therefore require decontamination if further injury is to be prevented.

The combination of first aid centres with decontamination centres has ~~to~~ many advantages that this arrangement is strongly recommended where possible, and it is our intention to carry it out. We propose providing cleansing facilities, both at our first aid posts and at our casualty clearing hospitals.

The purpose for which combined first aid and decontamination centres are required is to deal with all minor casualties which are not in need of immediate hospital treatment, and all cases of gas contamination in which serious injury has not already developed. This is laid down in A.R.P. Handbook No. 2 Chapter ^{vi}11, page ³⁷81.

The public are to be advised not to apply for treatment at hospitals, and that they will receive more prompt attention by going to a first aid post.

All such centres are to be equipped and staffed for the treatment of any, or all, of the following cases:-

1. Minor injuries caused by splinters, from high explosive bombs, falling masonry etc.
2. Casualties due to non-persistent gases.
3. Casualties described under 1 and 2 which are also contaminated with mustard.
4. Cases which are contaminated with mustard, but which are not yet casualties.

It is considered best to allot the accommodation in such a way that equal numbers of contaminated and uncontaminated persons can be dealt with.

It is laid down in Air Raid Precautions Memorandum No. 1 that sufficient posts should be provided in the built up areas of a County Borough to make it unnecessary for anyone to have to walk as much as a mile to reach the nearest post, but in less populous outskirts distances between posts can be increased. In our final distribution of first aid posts no person will have to walk more than eight hundred yards, except in the very outskirts of the city.

The selection of these centres has presented a very difficult problem. The Home Office have laid down two scales of accommodation one for large and one for small posts, and these are given in Appendix E. In practice, however, it has been found impossible to obtain existing buildings which give the accommodation as laid down, and we have had to select the best available according to situation.

The first move towards selecting sites for first aid posts was made by requesting all sanitary inspectors to supply a list of large buildings in their respective areas. A list of as many as 300 buildings was submitted. The inspectors at the same time supplied a map of each area showing positions of sites.

The final list was then scrutinised and over 100 of the suggested buildings were eliminated immediately as they were concerned with vital activities which could not be disturbed even in war time.

Approximately 100 more of the buildings remaining on the list were eliminated after a survey and a short list prepared. These were plotted out on a map of the city and the question of distribution was considered. It was then realised that it was almost essential that each building should belong to the Corporation as it was intended to draw up plans for certain structural alterations which would be required. Permission was obtained from the Heads of different Corporation Departments, and a large number of buildings were thoroughly scrutinised by the writer to ascertain their suitability.

A new aspect of the situation now became evident. Certain Wards of the City are nearly three times more populous than others. In addition certain areas on the outskirts are largely composed of fields or unpopulated land, and there are also a large number of parks scattered throughout the City.

A reference to the Map, Appendix C., will illustrate this point.

In order to get some idea of the relative population in each district the last census returns were referred to, and the distribution question reconsidered. At this stage it became evident that the population of certain parts of the City during the day was greatly in excess of that of the same areas during the night. In the district round the Clock Tower, which is regarded as the Centre of the City, it was estimated that the night population was some three thousand, whereas the day population was nearer twenty thousand. These figures were arrived at after a very careful study of the problem by ourselves in conjunction with the Transport (Tramways) Department.

When the question of bomb-proof shelters was gone into by the City Engineers Department a similar problem arose.

We have now decided that two mobilisation schemes will be necessary, one for daytime and one for the night. The same centres will be used, but those on the outskirts will be allotted more personnel during the "night" scheme, and less during the "day" scheme. This problem is discussed later when the question of personnel is explained.

In the final selection of sites for first aid posts the following factors were therefore considered:-

- a. Density of population during the day.
- b. Density of population during the night.
- c. No person to walk more than eight hundred yards, as far as possible.
- d. Suitability of buildings.
- e. Total number of posts limited according to personnel available.

The selected list of sites is as follows:-

1. Vestry Street Baths.
2. Cossington Street Baths.
3. Spence Street Baths.
4. Aylestone Baths.
5. Bath Lane Baths.
6. Abbey Park Pavilion.
7. De Montfort Hall.
8. Chester Street School.
9. Keyham Lane School.
10. Kinckley Road School.
11. King Richards Road School.
12. Melbourne Road School.
13. Upperton Road School.
14. Granby Road School.
15. Folville Rise School.
16. Overton Road School.
17. Linwood Lane School.
18. Granby Halls.
19. Leicestershire Tennis Club Pavilion.
20. Newark Girls School, and the Schools Clinic combined.
21. Corn Exchange.
22. Ashfield Road Bowling Club Pavilion.

The above sites are all marked out on the Map, Appendix C.

It should be noted that with the exception of the Tennis Club and Bowling Club Pavilions and the Granby Halls, all the above belong to the Leicester Corporation. The Granby Halls belong to Trustees on behalf of the public of Leicester, and are normally let out for various public functions, exhibitions etc. When the financial situation becomes less obscure it is proposed to take a long lease of these buildings, make our necessary alterations, and use them as a

training centre for our first aid personnel. Such conversion would not interfere with the normal function of the buildings, as very little structural alteration will have to be made. The situation is ideal as it is in close proximity to the Royal Infirmary which will be used as our chief casualty clearing hospital. A plan of the Granby Halls is given in Appendix F.

In addition to the first aid posts organised by the City authorities, centres are to be created in the adjacent villages of Birstall, Wigston, Oadby, Thurmaston, Anstey and Blaby. Plans for these are being prepared by the Leicestershire Air Raid Precautions Committee, but they will evacuate any serious cases to the City casualty clearing hospitals.

The matter of conversion into first aid posts of all the buildings selected under our scheme is now in the hands of the City Engineers Department. Plans are being drawn up by their architects so that such centres can be put into operation within seventy two hours of a state of emergency.

When the problem of the first aid post and decontamination centre is considered it is obvious that there will have to be a division into two sides, one for contaminated cases and one for "clean," and further contaminated cases will be sub-divided into those wounded, and those not wounded.

Each first aid post therefore should be prepared to handle three classes of casualty of each sex, and as each class calls for separate accommodation, a complete post will require six separate sets of rooms. In practice this cannot always be done, and in our plans for the majority of our posts we have been unable to allow for this.

Each post should however, be divided into three sections:-

- A. Wounded or gassed, who are not contaminated with persistent gas.
- B. Wounded or gassed, who are also contaminated with persistent gas.
- C. Unwounded persons whose skin or clothing is contaminated.

In those of our stations where there is limited accommodation those contaminated patients who require first aid can be transferred after cleansing to section A. And again, all cleansing of persons contaminated with gas, whether wounded or not, could be carried out in the same section if necessary.

An example will be taken of the proposed Granby Halls first aid post, and a brief description given as to how patients of each class will be dealt with.

Class A. patients. On arrival these will be admitted through the door reserved for uncontaminated patients. This door will be protected by an air-lock, as also will be all the other doors on the outside of the building. These patients will then be carried, or walk, direct to the treatment centre, where they will

be dealt with. If serious they will be transferred to the Royal Infirmary, if not, they will be treated and will be kept in the waiting-room until such time as it is safe for them to proceed to their homes.

Class B. patients. These will be admitted to the building through the door for contaminated persons. If possible grossly contaminated garments will be left in the shed outside the building. They will be undressed in the room allotted for this purpose, by personnel, protected by respirators and light oilskin clothing, who are specially trained for this work. The eyes will next be dealt with and lavage given by a skilled attendant after they have passed through an air-lock into the washing-room. Areas of skin contaminated by liquid mustard are now dealt with by an application of bleach ointment or paste, provided that the erythematous stage has not been reached. Patients are then soaped and washed as far as possible, depending on the seriousness of their wound or injury. This process is followed by drying and wrapping in blankets, and patients are then moved into the first aid rooms where their injuries are dealt with. On the completion of this the patients are taken to the waiting room where they are supplied with clothes and a record clerk takes down all particulars. This room is provided with a lavatory. The patients are kept here until such time as it is safe for them to proceed either to a casualty clearing hospital, or to their homes.

Class C. patients. These are dealt with in a somewhat similar manner as Class B. patients. As they are able to walk they will be able to rub their boots in a tin of chloride of lime placed in the shed outside the building before being admitted. They will also be able to shed any grossly contaminated garments. They will however, have to be undressed by the protected attendants in the same manner as Class B. cases. After they have been cleansed they will proceed to the waiting room which, like the other waiting rooms will be provided with a lavatory where they will be provided with fresh clothes, and as soon as circumstances permit, will be allowed to go home.

The following general points are of importance in the arrangement of every post and are being attended to in the plans.

- a. All lights must be obscured so that none are visible from the outside, particularly from the air.
- b. All external doorways must be either sealed or provided with air-locks.
- c. All buildings must be made gas-proof, and as far as possible, splinter-proof.
- d. To prevent damage from broken glass, glass roofs and ceiling lamps should be boarded underneath, or fine-meshed wire netting suspended close under.
- e. All rooms will require to be warmed in winter.
- f. Where it is desired to divide a large hall up into smaller rooms moveable partitions would be useful as these could be improvised and need only be seven feet high. They should be of a type that is not easily knocked over.

- g. Accommodation for contaminated patients must be such that vapour cannot spread into the "clean" section of the building.
- h. Contaminated casualties must not use the same entrances and passages as are used by uncontaminated patients.
- i. Alternative illumination such as hurricane lamps must be provided. Similarly water should not be heated solely by gas or electricity.
- j. The tanks, etc., for storage of water should be ample, in case the external supply is interrupted by bomb damage.
- k. Each complete post for both sexes should, if possible, be in one set of premises. When this cannot be arranged posts for men and women should not be more than one hundred yards apart and, if possible, within sight of one another.

During the War the American Army gas specialists evolved what was known as "a motorised mobile de-gassing plant" and the object was to provide early bathing facilities for contaminated troops. The equipment consisted briefly: of a motorised tank capable of carrying twelve hundred gallons of water, with a pump and special heating device. Twenty four shower heads in three separate independant section frames could be attached to the tank. The shower heads were supported when required, on a portable iron frame with sliding joints. By this means twenty-four men could be bathed in one minute and a half. To establish the plant in a building took two minutes, but if a tent had to be erected seventeen minutes were required.

In the event of mustard or Lewisite spray being a more potent weapon than we anticipate it is possible that very large numbers of the public in a small area may be contaminated without being wounded. If this

should happen the pressure of work on Section C. of the nearest first aid post will be overwhelming. Some means of emergency help will be required, and it is thought that a scheme similar to the motorised mobile de-gassing plant of the Americans would prove useful. This might also prove more practical than transferring large numbers of patients to other posts in order to relieve the situation. One or two such vehicles could be kept at headquarters and rushed to the scene of emergency, should occasion arise. The showers could be utilised to supplement those already in existence at the aid post or an auxilliary decontamination centre could be set up in adjacent building. The suggestion is worthy of consideration provided that suitable modifications could be worked out.

A scale of equipment for first aid posts is given in Air Raid Precautions Handbook No.2, page 108, but is not described here, as we find in practice that the equipment required for each individual aid post and decontamination centre will vary tremendously.

The staff required for each first-aid post varies again as to whether the post is small or large. The total staff for each shift in a complete post is summarised in Air Raid Precautions Handbook No. 2. as follows:-

| | Male side & general | Female side |
|---|------------------------|--------------|
| Officers | 1 | 1 |
| Fully trained first aid personnel | 8 | 8 |
| Auxilliary trained first aid personnel | 11 | 11 |
| Storemen | 2 | 1 or 2 |
| Clerks | 4 | 3 or 4 |
| Furnaceman | 1 | - |
| Domestic staff | as required. | as required. |
| Doorkeepers | 1 | 1 |
| <u>Totals.</u> | 28 | 25 or 27 |

It is evident therefore that the total number of personnel required to run a large first aid post and decontamination centre such as the Granby Halls will be fifty-five men and approximately fifty women. A post of the smaller type would require proportionately less. Of the above, forty men and forty women will be trained members of the St. John Ambulance Brigade, and the remainder will be recruited from volunteers.

One converted motor ambulance vehicle will be attached to each first aid centre.

Each first aid centre presents a problem in itself, and an immense amount of time and study have been spent on this subject. It is not proposed to describe the individual details of our posts in Leicester in this thesis, as each post would require a separate description.

CHAPTER XII.

CHAPTER XII.CASUALTY CLEARING HOSPITALS.

Casualty clearing hospitals should normally be the local hospitals where operating theatres and beds would be available for the more serious types of casualty. It is proposed that on a threat of air attack beds in these hospitals should be freed by the evacuation of a proportion of patients who can be removed with safety, and that thereafter no patients should be accepted for lengthy treatment. As is indicated, when discussing individual hospitals, such patients will be transferred, either to a convalescent home, a poor law institution, or to their respective homes.

Following a raid no casualties who are fit to be removed will be retained in a casualty clearing hospital, but will be transferred to one or other base hospital. Thus as many beds as possible will be kept free for further casualties, and the evacuated cases will also be moved to an area less likely to suffer air raid damage.

It is impossible to attempt to prevent injured persons proceeding direct to a hospital. Hospitals however, will not be expected to cater for people who are contaminated without being injured. For one thing they will not have clean outdoor clothing available to give away to replace contaminated cloth-

ing. Similarly a multitude of walking wounded or slightly injured cases descending on the hospital would seriously impede the efficiency of the staff whose time will be fully required dealing with seriously injured members of the public.

We therefore propose to create a large first aid post at the Granby Halls in the immediate vicinity of our chief casualty clearing hospital. This first aid centre will deal with all unwounded contaminated, and slightly injured cases arriving at the hospital, and will ease the strain very much.

Casualty clearing hospitals will however, have to be prepared to cleanse seriously injured patients who are also contaminated, before admitting them into the wards. The type of accommodation for cleansing and decontamination will follow the lines as already described for a first aid party depot. Necessary adaptations are being worked out by members of the City Engineers staff, and plans are being prepared for the conversion of part of the Out Patients Department in our main casualty clearing hospital into a decontamination centre.

The Home Office have stated that the city of Leicester requires to have 200 casualty clearing beds ready at the start, and 240 beds at the end of the first week after the outbreak of hostilities.

The whole question of hospital bed accommodation has been gone into with the neighbouring Leicestershire

County Council Air Raid Precautions officials. It is obvious that to get the best results very close co-operation will have to be maintained, as the County will have to evacuate a high percentage of their possible casualties into City hospitals.

The Leicester Royal Infirmary will be used as the main casualty clearing hospital, with the Faire and Regent Road private hospitals as auxillaries.

Additional hospital accommodation in Leicester consists of the City General Hospital and a poor law institution which is used for the treatment of chronic sick only. There is no other relevant hospital accommodation within the City boundaries, with the exception of a first class infectious diseases hospital and sanitorium just inside, which belongs to the Corporation, also a mental hospital, which however, does not enter into our scheme.

Major Stuart Blackmore of the Home Office has advised that infectious diseases beds, tuberculosis beds, mental diseases beds, maternity beds and orthopaedic beds will on no account be used for Air Raid Precautions purposes.

Further we have been advised that the Army and Navy are not to use civilian hospitals after one month from the commencement of hostilities.

Leicester Royal Infirmary. Is a voluntary hospital of approximately 500 beds which are constantly in use.

It is a well equipped, modern hospital with ample operating theatre accommodation, an up-to-date X-Ray

Department and a large Out-patient Department. The accommodation in the Accident Ward is somewhat limited, but this is to be extended in the near future.

In conjunction with the hospital authorities we have estimated that immediately following a state of emergency 50% of the total beds could be evacuated, some of the patients being sent to their homes, others to Swain Street poor law institution and others to the Convalescent Home at Swithland.

Subject to bedsteads and mattresses being available and a corresponding increase in the medical and nursing staffs being catered for, it is estimated that the total capacity of the Royal Infirmary could be increased, in a state of emergency, by a further 300 beds at the end of one week. This figure has been arrived at after consulting the Matron of the hospital, who informs us that an additional 75 nurses would be required to manage these beds. Of this increase in staff fully one half would require to be trained nurses.

The question of the provision of any additional personnel is discussed later under a special heading.

On arrival at the Royal Infirmary any contaminated patient will be cleansed. All cases will be seen immediately by a Medical Officer who will order their distribution to the various wards in the hospital. Members of the clerical service will be on duty to keep records of all casualties. Separate wards will

be required for septic broncho pneumonia cases following mustard, for the "blue" and "grey" types of phosgene cases, for severe skin lesions due to mustard and Lewisite and for eye cases. At least two wards will be required under each section, one for each sex.

The particular wards set aside for the treatment of lung irritant casualties will require to be specially equipped so that oxygen treatment can be provided. A tank and piping will be required to lead from the cylinders to the patients besides. It is hoped that this equipment will be fitted in the near future. A full description of the method of oxygen administration is given in Air Raid Precautions Handbook No. 3, Appendix 3. We consider that this is one of the most important functions that may be required of the hospital, and have strongly advocated that these wards should be fully equipped and ready long before the possible commencement of any hostilities.

Plans are being drawn out for the gas-proofing of the hospital and for certain weak spots, which may be easily affected by the blast from high explosive bombs to be strengthened. This question is being gone into in great detail, measurements have been taken, and the amount of material required for air-locks, light-proof curtains, shoring material and sand-bags is being estimated. We consider that it is essential that this material should be secured and kept in stock so

that, in the possible event of an outbreak of war, the very essential function of the hospital would be interfered with as little as possible. The method of gas-proofing and light restriction used by us, are taken from Air Raid Precautions Handbook No. 6.

The Faire Hospital is a small institution which takes in paying patients. Normally there are 30 beds available, but it is very seldom that they are all in use.

It is estimated that the capacity of the hospital could be easily extended to 70 beds in a state of emergency at the end of the first week. This could be done by using balconys and sideways, and by slightly increasing the number of beds per ward.

There are two operating theatres, but no X-Ray plant is available.

It would be difficult to arrange for decontamination facilities at this hospital, and it is suggested that only patients who are not contaminated in any way with persistent gas should be sent. This could easily be done by instructing all first aid parties to this effect.

Anti-gas preparations and preparations for the restriction of lighting are being made on similar lines to those for the Royal Infirmary.

The Regent Road Private Hospital is a small hospital for paying patients. There are normally 46 beds occupied, and the hospital is generally full.

It is estimated that fully half the number of beds could be evacuated at short notice.

The capacity of this hospital could be increased to 80 beds at the end of a week, and to 120 beds at the end of 3 weeks. This is subject to bedsteads and mattresses being available. A large increase in the trained staff would not be required, but a number of V.A.D. men would be required.

It is suggested that 100 of the available casualty clearing hospital beds be allotted to the County authorities. This makes the estimated total number of beds available at the start as follows:-

| | |
|----------------------|-----|
| Royal Infirmary | 250 |
| Faire Hospital | 30 |
| Regent Road Hospital | 20 |
| <u>Total</u> | 300 |

Estimated number of beds available at the end of 1st week:-

| | |
|----------------------|-----|
| Royal Infirmary | 550 |
| Faire Hospital | 70 |
| Regent Road Hospital | 80 |
| <u>Total</u> | 700 |

CHAPTER XIII.

CHAPTER XIII.BASE HOSPITALS.

This problem has also been provisionally discussed with the Leicestershire authorities as the City will have to evacuate a certain number of its casualties into the County. The Home Office recommend that places in rural areas should be selected as far as possible, but that base hospitals should not be so far from the Borough as to create serious transport problems.

The Home Office have stated that Leicester will require the following beds in base hospitals:-

| | |
|----------------|-------|
| Ready at start | 400 |
| End 2nd week | 795 |
| " 3rd " | 995 |
| " 1st month | 1,295 |

The following will be used as base hospitals:-

- a. City General Hospital.
- b. Leicester Frith.
- c. South Charnwood Modern School.
- d. Church Langton Modern School.

a. The average number of beds available in the City General Hospital is five hundred and fifty. As is indicated by the title this is a municipal hospital and is well equipped in every way. There are two operating theatres and an up-to-date X-ray plant. There is no Out Patient Department, as it is situated on the outskirts of the City.

In conjunction with the hospital authorities we have estimated that immediately following a state of emergency fifty per cent of the beds could be evacuated

some of the patients being sent home, others to Swain Street Institution and others to the Swithland Convalescent Home.

Subject to bedsteads and mattresses being available and a corresponding increase in the medical and nursing staffs being arranged, it is estimated that the total capacity of the hospital could be increased by a further hundred beds at the end of the first week, and another two hundred at the end of the first month. This figure has been arrived at after consulting the Matron of the Hospital, who informed us that more patients could be accommodated if the kitchen accommodation were extended, and the nurses quarters very much enlarged. The figure two hundred and fifty is based on the present arrangements of the hospital.

In the event of one or other of the casualty clearing hospitals being put out of action the City General Hospital will have to take on the duties of a clearing hospital as well as a base hospital. In any case casualties which occur in the immediate vicinity of this hospital will be admitted direct instead of carrying them over to the Royal Infirmary.

Cleansing and decontamination facilities will be available in the receiving part of the hospital, and trained personnel will be in attendance to deal with any contaminated cases.

Plans are being drawn up by the City Engineers Department with the view to making this hospital splinter-

proof. gas-tight and light-proof as far as possible.

b. The Leicester Frith is an institution for the resident treatment of mental defectives, and is situated on the City boundary. It is a comparatively recent building and is well suited for our purpose as a base hospital. Practically no conversion is required. The normal capacity of the Frith is one hundred and fifty-seven male beds, and one hundred and thirty-nine female beds, making a total of two hundred and ninety-six. It is thought that immediately following a state of emergency all these patients could be evacuated, either to their homes or to Swain Street Institution. Subject to bedsteads and mattresses being available it is estimated that the total capacity of the hospital could be increased by a further one hundred beds at the end of the second week. Gas-proofing and splinter-proofing plans are being drawn up.

c. South Charnwood Modern School is situated about five miles from the City boundary in the heart of Charnwood Forest. It is surrounded by woods and lies in a valley. The school is a very large one, and the Leicestershire Air Raid Precautions authorities intend provisionally to establish a large base hospital of eight hundred beds on this site. They would be prepared to allow two hundred and fifty of these beds for the use of cases evacuated from the City, at the end of three weeks from the outbreak of hostilities. The

plans for the conversion of this school into a hospital are being drawn up by the County Council authorities.

d. Church Langton Modern School is situated about seven miles from the City boundary on the South side. The school is a very large one and the Leicestershire Air Raid Precautions authorities intend provisionally to establish a base hospital of seven hundred beds in this building. They would be prepared to allow us two hundred of these beds at the end of four weeks from the outbreak of hostilities. The plans for the conversion of this school into a hospital are being drawn up by the County Council authorities. It is admitted that this hospital is rather a long way from the City, but for the type of case requiring freedom from anxiety and rest it would be ideal.

The Convalescence Homes at Swithland and Desford are situated approximately six and ten miles respectively from the City boundary and have not been included at present in the base hospitals scheme. Normally there are one hundred and nine beds available at these centres. It is probable however, that the majority of these beds would be required for the discharged cases from the central hospitals when the state of emergency is declared. It is possible however, that, at a later date, a few of these beds might be available for Air Raid Precautions purposes.

Swain Street Poor Law Institution is situated near

the centre of the City, but is not included in the Air Raid Precautions scheme as the accommodation will probably be required for such mental defectives from the Frith as cannot be sent to their homes and for discharged medical cases from the Royal Infirmary and City General Hospital. This Institution could take one hundred mental defectives and one hundred and fifty extra bed cases without any alteration. There is no operating theatre, and patients requiring active surgical treatment cannot be catered for.

It should be noted that provisionally, the County Authorities will be able to allow us four hundred and fifty beds by the end of the first month. In return for this concession it is suggested that all infectious, scarlet fever and diphtheria cases in the Leicestershire Isolation Hospital at Markfield should be transferred to the City Isolation Hospital at Groby Road. The outside limit to this number would be fifty-four patients in all, and in practice the total would probably be much less. This would enable the Medical Officer of Health for the County to establish a casualty clearing hospital at Markfield, and would greatly simplify his scheme. In addition to this, as has already been stated, we are helping the County Authorities by providing one hundred casualty clearing hospital beds in the City, for their use.

The following gives the scheme of expansion for base hospital beds:-

a. Estimated total number of beds available at the start:-

| | |
|-----------------------|-----|
| City General Hospital | 275 |
| Leicester Frith | 296 |
| <u>Total.</u> | 571 |

b. Estimated total number of beds available at end of second week:-

| | |
|-----------------------|-----|
| City General Hospital | 375 |
| Leicester Frith | 396 |
| <u>Total.</u> | 771 |

c. Estimated total number of beds available at end of third week :-

| | |
|-------------------------------|-------|
| City General Hospital | 375 |
| Leicester Frith | 396 |
| South Charnwood Modern School | 250 |
| <u>Total.</u> | 1,021 |

d. Estimated total number of beds available at end of fourth week:-

| | |
|-------------------------------|-------|
| City General Hospital | 575 |
| Leicester Frith | 396 |
| South Charnwood Modern School | 250 |
| Church Langton Modern School | 200 |
| <u>Total.</u> | 1,421 |

Part of the staff of the City General Hospital and the Leicester Frith have already received anti-gas training. The staffs of the remaining hospitals will receive such training in due course.

CHAPTER XIV.AMBULANCE SERVICES.

Ambulance motor vehicles will be required,

- a. For evacuating ordinary cases from hospitals selected to be casualty clearing hospitals, to their homes, or another institution.
- b. For transporting casualties picked up by first aid parties to casualty clearing hospitals.
- c. For transferring serious cases from first aid posts to casualty clearing hospitals or base hospitals.
- d. For transferring cases from casualty clearing hospitals to base hospitals.

In the City of Leicester there are only eight available motor ambulance vehicles. Three of these belong to the St John Ambulance Brigade, and five are attached to the Fire Brigade.

Under our scheme a large number of additional ambulance cars will be required, and it is proposed to obtain these by converting certain trade vehicles.

It is estimated that the additional ambulance cars required will be posted as follows :-

| | |
|--------------------------------|----|
| First Aid party depots | 32 |
| Central First Aid party depots | 10 |
| First Aid posts | 21 |
| Reserve | 12 |
| <u>Total.</u> | 75 |

It is seen from the above that the auxiliary vehicles will be used to bring patients in to the casualty clearing hospital, and it is suggested that the eight permanent vehicles be kept for the purpose of evacuating cases from the casualty clearing hospitals to the base hospitals.

The scheme for the decontamination of all motor ambulance vehicles has been prepared by the Transport

Department, who will undertake all such work.

Personnel for the auxiliary motor ambulance service are being recruited by the Corporation, and will be trained in first aid work and anti-gas measures. All drivers of such vehicles will wear protective clothing of the light type and will be supplied with a service respirator.

The ambulance service will be administered by an officer in charge, who will be appointed from the Transport Department. He will be supplied with three assistants and eight sub-assistants. The organisation of the scheme is very much de-centralised, and will require a vast amount of supervision. As has already been mentioned, we have adopted de-centralisation because of the comparative failure of the systems tried out in the Southampton manoeuvres.

Several plans for the conversion of covered tradesmen vans into ambulance cars have been investigated, but the most practical of those seen so far is that issued by the Huntingdonshire Air Raid Precautions Transport Committee. By this means any covered tradesmans van from 10 to 15 cwt. can be converted into a vehicle capable of carrying two stretcher cases or six sitting cases. It is also so designed that an ambulance party from six to eight in number can be conveyed with reasonable comfort from the point of assembly to the scene of action. The mechanism can be constructed in two hours and can be fitted to a van in a further thirty minutes. The details are given in Appendix G.

A list is being prepared of all firms who are willing to allow the Air Raid Precautions authorities to use their vans in a time of emergency. It is not anticipated that there will be any difficulty in recruiting the required number of vehicles.

CHAPTER XV.

LAUNDRY SERVICES, (DECONTAMINATION OF CLOTHING, ETC.)

An organisation will be needed for decontamination of clothing, and for this purpose certain laundries in the City have been earmarked. A list is given below:-

- a. Roughton Street.
- b. Barkby Road.
- c. Gipsy Lane.
- d. Cyprus Road.
- e. Rawson Street.
- f. Harrison Road.

It has already been mentioned that mustard and Lewisite are comparatively easily destroyed by steam and the laundry is therefore the obvious centre for decontamination of clothing. The above are all well equipped modern laundries, and it is surprising how little change will need to be made for their adaptation to the purpose of decontaminating clothing. Certain flues and air channels may require strengthening and other slight alterations, and the question has been gone into and plans are being drawn out for such alterations that are required.

Personnel who will be handling this work will however, require very special training. The Corporation have had an instructor trained at the Civilian Anti-gas School for this purpose, and already a number of men have been, in turn, trained by him. Up to the present these have been Corporation employees only, but it is hoped that some arrangements can be made with the laundries to train a percentage of their own workmen by the same instructor.

All personnel handling contaminated clothing, or who are working on the contaminated side of the building will require light protective clothing and service respirators.

Certain methods of decontamination are described in Air Raid Precautions Handbook No. 1, section 24.

Arrangements are being made by the Cleansing Department for the transport of all bins containing contaminated clothing to the appropriate laundries. Members of the public who have become contaminated with any form of persistent gas, and who undress at home are advised to place the affected clothing in a bin or other suitable container, and convey same to the nearest first aid post where it will be handed over to the Cleansing authorities.

Leather boots are not suitable for the ordinary methods of decontamination, and require special treatment. This side has again been handed over to the Cleansing Department who are arranging for a special centre which will deal with such articles.

Contaminated stretchers will be dealt with at the laundries as also will be respirators.

Plans are being drawn up for this essential service so that all buildings can be made gas-proof, splinter-proof and light-proof.

The laundry at Knighton Fields will be reserved for the decontamination of contaminated clothing of Air Raid Precautions personnel.

CHAPTER XVI.

Clerical Services. Records Section. Clerical staffs will be required to enable records to be kept of casualties and their treatment at every first aid post and every hospital. The arrangement for the custody of patient's clothing and valuables will be undertaken by this branch of the service. A central record section will also be required.

This service will be organised and administered by an officer in charge, who will be chosen from one of the Municipal departments. Personnel for this service will be recruited from known and trusted Municipal employees. Their work will entail much responsibility as they will have charge of all articles of value taken from patients at first aid posts and hospitals.

All members of this service will be trained in anti-gas measures.

Personnel. On the medical side of the scheme personnel will have to be specially enrolled for casualty services. The following will be required:-

- a. Medical practitioners.
- b. Trained nurses.
- c. First aid men for outside work.
- d. First aid men for inside work.
- e. First aid women for inside work.
- f. Auxilliary ambulance vehicle drivers.
- g. Clerks.
- h. Trained laundry workers.

Air wardens, trained chemists for detector work and rescue parties do not come under the Medical Officer of Health for administration, and are therefore not discussed here.

a. Medical Practitioners. The assistance of a number of private medical practitioners will be essential. As far as possible older doctors, say over forty, have been asked to assist in this part of the scheme. Practitioners will be required to supplement the staff of the Royal Infirmary, to provide a staff for the Faire and Regent Road private hospitals and to provide medical staffs for the various base hospitals. It is estimated that the following will be required:-

| | |
|---|----|
| i. Royal Infirmary. | 12 |
| ii. Faire Hospital. | 5 |
| iii. Regent Road Hospital. | 8 |
| iv. City General Hospital (extra) | 8 |
| v. Leicester Frith | 10 |
| vi. South Charnwood School Base Hospital | 5 |
| vii. Church Langton School Base Hospital | 5 |
| viii. Swain Street Poor Law Institution (extra) | 2 |

This makes a total of fifty five and does not include surgeons, of whom there are ten practising in the

City. The distribution of these would be left to the senior surgeon at the Royal Infirmary.

The Home Office instructor for the district, Dr. Rankine, has already given a detailed course of lectures and demonstrations to the local medical society. A further number of local practitioners are being trained under the auspices of the St. John Ambulance Association.

Following instructions received from the Home Office we do not propose to attach Medical Officers to first aid posts.

There are approximately two hundred medical practitioners in Leicester. Of these it is thought that thirty are connected with one or other branch of the fighting services and would be called up immediately. In addition no doubt a number of the younger men would volunteer for active service in the field. When we subtract the fifty-five required for our scheme we see that there will not be a large percentage left to attend to the normal sick of the City.

b. Trained Nurses. It is certain that when a state of emergency arises there will be a very acute shortage of trained nurses in this district. A large number of the nursing staffs of the local hospitals are members of the Territorial Army Nursing Service, and will be called up on the outbreak of war. In addition to this, with the exception of the Royal Infirmary, most of the other hospitals are already short of trained staff.

Fortunately both the Royal Infirmary and the City General Hospital are training centres for nurses, and the problems have been discussed with the respective Matrons. It is hoped to enlarge the nurses accommodation in the near future, and so allow us greater numbers of trained nurses. It is not proposed to call on the local visiting District Nurses Association for any help as all their time will be taken up with nursing the cases discharged from hospital to provide us with beds, and in assisting the nursing of such slight casualties as may be sent home for treatment.

The local secretary of the Royal College of Nursing has been interviewed, and the College has agreed to assist in the formation of a reserve of nurses for Air Raid Precautions purposes. This reserve will be made up from local private nursing associations, local private visiting nurses, retired nursing sisters and qualified nurses who have married and who live in the vicinity.

It is hoped to obtain thus a fair number of experienced nurses. They will receive training under the auspices of the College of Nursing as soon as this can be arranged.

It is estimated that the following will be required:-

| | |
|---|-----|
| 1. Royal Infirmary | 25 |
| 2. Faire Hospital | 10 |
| 3. Regent Road Hospital | Nil |
| 4. City General Hospital | 25 |
| 5. Leicester Frith | 40 |
| 6. South Charnwood School base hospital | 25 |
| 7. Church Langton School base hospital | 20 |
| 8. Swain Street Institution | 5 |

This makes a total of 150. This figure is arrived at by allowing one trained nurse to each ten beds, but in addition there will be one voluntary aid detachment nurse allotted to every trained nurse.

Special training will be given to all of the above nurses, as far as possible, in anti-gas measures and in the special treatment required for gas casualties.

c. & d. First aid men for both outside and inside

work:- The local branch of the St. John Ambulance Brigade have undertaken to try to provide the personnel for this branch of the service but numbers may be limited. They expect us to give them every assistance in recruiting. This will be done by the opening of a recruiting office under the auspices of the Corporation. The Brigade intend to form a special reserve unit for Air Raid Precautions purposes which will be attached to and administered by their own officials.

Several difficulties arise in the preparation of this part of the scheme. Preferably younger men under thirty years of age who might want to enlist will not be taken. Again a fair proportion of the existing brigade are members of the special Army reserve and the

Naval Sick Berth Attendants Reserve, and will be called up on the outbreak of war. Men who fall into either of the above groups will therefore not be enlisted under our scheme. Another great difficulty is the fact that in Leicester many members of the Brigade live at least two miles from the place of their normal work. In the event of mobilisation before an air raid these men would not have time to get to the scene of their Brigade duties unless they are posted close to their work for the day-time, and close to their homes for the night. Two separate mobilisation schemes are therefore being prepared one which will come into existence between the hours of 8 a.m. and 6 p.m., and the other which will cover the remaining hours of the twenty-four. It has already been explained how the "night" scheme for first aid posts differs from the "day" scheme, and the posting of Brigade personnel will follow these lines. A further feature which increases the difficulties faced by the St. John Ambulance Brigade is the fact that many of its members are employed by firms who are preparing their own first aid schemes. Naturally these firms insist on their own employees helping in the firms individual scheme should there be a raid during working hours.

The following observation was made after the recent Southampton manoeuvres. "The general standard training of "inside" Medical Services personnel was

fairly high. This comment however, does not apply to "outside" workers, and clearly emphasises that first aid or stretcher parties will require a specialised training, as much of their work will be of an isolated character. Special steps are being taken here in Leicester to insure that all-round training will be given. It is intended that all St. John members will be inter-changeable either for first aid post work or first aid party work.

Training is being carried out by the Brigade's own instructor, assisted by Falfield trained instructors on the staff of the Corporation.

The Jarvis Street depot already mentioned is to be used for training Brigade, as well as, Corporation personnel. It is hoped that the arrangements already suggested for the completion of one first aid post for training purposes will be carried out within the next few months. This will greatly stimulate enthusiasm among the St. John Brigade, whom it must be remembered, are **all** volunteers, and receive no payment for any of their services.

The total number of male personnel to be supplied by St. John Ambulance Brigade is 1,184.

e. First-aid women for inside work. The St. John Ambulance Brigade have undertaken to supply us with the personnel for this branch. The female side of the local brigade is well up to strength, and there should be no difficulty in obtaining volunteers.

Women of any age may be accepted, but the younger and stronger members are being chosen for work in the first aid posts. Training in anti-gas measures, first aid, and the specialised nursing of gas cases is being undertaken by the Association itself. The Corporation instructors are giving assistance as required.

The following numbers will be necessary:-

| | |
|--|-----|
| For first aid posts | 880 |
| " Royal Infirmary | 25 |
| " Faire Hospital | 10 |
| " Regent Road Hospital | 40 |
| " City General Hospital | 25 |
| " Leicester Frith | 40 |
| " South Charnwood School Base hospital | 25 |
| " Church Langton School base hospital | 20 |

Total. 1,065

f, g. & h. The question of auxilliary ambulance drivers, clerks, and trained laundry workers has already been discussed. Recruitment for all these services will be made under Corporation auspices, and their training will be done by the Corporation instructors.

CHAPTER XVII.

CHAPTER XVII.EQUIPMENT.

Vast quantities of additional medical equipment will be required. It had been hoped that before this thesis was completed the financial situation would have been somewhat cleared up. It is however, still very obscure, and this factor makes it difficult for us to discuss how equipment is to be obtained. As soon as the money matters are settled we will be able to proceed with this aspect of the problem.

The heads of several firms in the City have been approached on the subject of stocks, and we in Leicester are fortunate in having the two great firms of St. Dalmas and Browns Ltd. in the city. It is probable that as far as actual medical equipment is concerned these two firms will be able to meet us for any specific quantity required. It is hoped that eventually when financial questions are settled, six-monthly contracts will be arranged and remuneration settled on turn-over. Explained briefly, this means that in return for an agreed sum of money these firms may be prepared to increase their holdings of stock so that, in a state of emergency, we should have the actual materials here within the precincts of our own City. Naturally the whole of the stock would not be paid for until actual delivery.

The question of equipment for first aid parties has been gone into, and our special modification will

eventually be produced. It is hoped that we shall be able to arrange for this equipment to be held by wholesale houses in the district until called for. The manufacturers are prepared to send an inspector round at definite intervals to see that the materials are being properly stored.

It is regretted that for business reasons we are not allowed to publish any further particulars or details of this part of the scheme at present, but we are quite satisfied that if the occasion should ever arise there will be no shortage of medical equipment, bandages, dressings, splints etc. in this City.

The supply of oxygen however presents a separate problem in itself. Oxygen cannot be kept, even in new cylinders, for more than six months, as there is constant wastage. An inquiry was made to a local firm of oxygen wholesale dealers, and we find that the matter has been taken up by the Government direct with the British Oxygen Company, who hope to solve the problem.

From the estimates it is calculated that twelve hundred and sixty additional hospital beds and mattresses will be required before the end of a month from the declaration of war. As mattress making is an important industry in Leicester and there are several large firms in the City, each of whom hold good stocks, it is not anticipated that there will be much trouble over obtaining these. To make sure however, firms were approached and all that is necessary is

the provision of some arrangement whereby these firms will be encouraged to increase their stocks by some fifty per cent. Hospital bedsteads however, present a serious problem. There is no manufacturer in or near Leicester. To make a contract with a firm some distance away is rather a risky proceeding, as in a state of emergency one would have no guarantee of immediate delivery. There are some fifty bedsteads in reserve at the City General Hospital, and over one hundred available bedsteads not in use at Swain Street Institution. Enquiries made round the furniture shops in the City have elicited the fact that not more than a dozen hospital beds could be obtained at short notice. It is probably therefore that we shall have to buy outright approximately two hundred beds, and keep them ourselves, and to trust to some form of "dormant" contract being arranged to provide the remainder when required.

We have recently inspected a small portable, and cheap camp bed invented by an enterprising manufacturer. This gentleman is prepared to let the Corporation have a dormant contract for a thousand beds for a very small annual fee. These beds however, are not suitable for nursing cases as they are much too near the floor.

Thus we see the bed question is not yet settled, but it is hoped that the whole problem will be solved at an early date.

The provision of blankets, sheets and hot water bottles presents no difficulty. In addition to one or two wholesale warehouses, numerous shops, both large and small hold stocks of these every day commodities. In the unlikely event of their being a shortage, an appeal would promptly be made to householders to lend or sell us spare sheets and blankets.

Approximately four hundred stretchers will be required, and these must be available from the very outset of hostilities. This has been calculated as the minimum number necessary, and it is thought that these will have to be purchased as soon as a financial agreement is reached. In the meantime, pending the possible outbreak of hostilities, they would be used for training purposes. It has been decided provisionally that the "A" type of stretcher (as supplied to the Police and St. John Ambulance Brigade) will be used in our scheme.

No-one has yet been able to suggest from whence the large amount of clothing necessary for the first aid posts is to come. If good new clothes are provided one can foresee a great demand being made on our resources, probably rather more than strictly necessary. On the other hand if the clothes provided are too shabby, fastidious people will refuse to wear them. It is thought however that vast quantities of clothing will have to be purchased from wholesale warehouses in the City immediately following

a state of emergency. There should be no shortage of either clothing or shoes in our City, as the manufacturer of these form its two major industries.

In the event however, of a succession of air raids in which persistent gas is used we should probably have to issue clothing similar to the "Clothing, Hospital" of the Army. The provision of hospital "blue" would insure its safe return to the authorities.

The remainder of the equipment required could be purchased at short notice, but the whole problem is one which still requires very serious consideration.

CHAPTER XVIII.

CHAPTER XVIII.EDUCATION OF A CIVILIAN POPULATION.

In order to minimise the number of casualties resulting from an aerial attack, the general public must be instructed as to the possibilities and limitations of air gas attack. The individual must have such knowledge as will enable him to act intelligently and concert with the general defence plan. As has already been mentioned, the medical man who has taken the trouble to provide himself with an extensive knowledge of the subject will be invaluable.

Instruction of the public should proceed along the following lines.

During an attack all normal activities of the community are necessarily suspended, and methods of communication have been instituted to insure adequate warning of from fifteen to thirty minutes of a raid.

Safety from gas will be much greater indoors than out. Non persistent gases are all heavier than air and no appreciable quantities will enter buildings unless drawn in by positive drafts. Liquid agents will seldom penetrate buildings, and their vapours are readily excluded by tightly closed windows and doors.

It is the intention of His Majesty's Government to supply every civilian in time of war with a respirator or gas mask which will protect the eyes and respiratory passages from every known type of war gas.

It is essential however, that the civilian be instructed as to the fitting and rapid adjustment of his respirator, as a very short interval may represent the difference between danger and safety.

Even if shelter is not available and one must remain in the open, serious gas injuries may still be avoided by cool and intelligent action. Particularly to be avoided is the sprinkling of mustard or Lewisite from low flying planes. If unable to obtain cover during such an attack, protection may still be had by drawing a garment, or even an umbrella over the head; either being immediately discarded after it has served its purpose.

Areas contaminated with mustard or Lewisite should be avoided by all except those actively engaged in decontamination work.

Gas never engulfs the city as a whole, and the best that an attacker can hope to accomplish is to pepper a few important sections with chemicals, which once released, immediately become subject to the destructive forces of nature.

Even if moderate exposure is inescapable the resulting injury may often be counteracted by first aid measures such as those already mentioned. In cases of severe exposure medical attention must be obtained, but most gas injuries resulting from the limited quantity of chemicals that can be released in the aerial attack of cities may be remedied by proper treatment.

Vapours are to be countered by seek an atmosphere of fresh air, and it must be remembered that in the case of all chemical agents the area of destruction includes part of the neighbourhood down wind from the centre of release.

If gassing of any degree is suspected it is important for the individual to remain quiet once he is out of the gas area, to avoid all exertion and to await medical advice.

Persons who believe that they are contaminated by mustard or Lewisite should make their way to a first aid or decontamination station in order to have thorough and efficient treatment and a change of clothes. Where no such station is available contaminated clothing should promptly be got rid of, and the body sponged with a solvent such as petrol, followed immediately by bathing with hot soapy water.

All efforts to escape personal injury during air attacks are furthered by the single rule - avoid crowds. When the human targets are widely dispersed gas not only becomes a blunt weapon, but each individual is permitted wider freedom of action to seek his own safety.

In teaching the public how to choose a refuge room, the following points are emphasised:-

- a. Any room will serve if it can be made air-tight, if it is soundly constructed and easy to reach.
- b. A room that looks out over a garden or soft ground is better than one which has a hard ground surface outside.

- c. A room which faces a building or blank wall is better than one exposed with windows facing several ways.
- d. The stronger the walls, floor and ceiling are the better.
- e. Brick partition walls are better than plaster.
- f. A concrete ceiling is better than a wooden one.
- g. A room on the ground floor or a basement or cellar is better than the top floor provided there is no likelihood of flooding. In a tenement house top floor people should find accommodation downstairs as small incendiary bombs are capable of piercing the roof, but are unlikely to get below the top floor.

Although an actual raid may be over in a few minutes it may be necessary for members of the public to stay in their refuge rooms for some time, even perhaps an hour or more, until gas in the neighbourhood has been cleared away. It is therefore important that the public should know how many persons can remain safely in one room without suffering any ill effects. For rooms of normal height (eight or nine feet), an allowance of twenty square feet of floor area for each person will enable them to remain in the room with complete safety for a continuous period of twelve hours without ventilation.

A room 10 ft x 10 ft will hold 5 persons.

A room 15 ft x 10 ft will hold 7 persons.

A room 20 ft x 15 ft will hold 15 persons.

A room 30 ft x 15 ft will hold 22 persons.

It is not thought however, that people will have to spend as long as twelve hours at once stretch in

their refuge rooms, but these figures are given so that over-crowding can be avoided.

The various methods of rendering a room gas-proof are not considered as part of the medical aspect of the scheme. The public will however, be taught several different ways of achieving this object as it is the intention of the Government to issue a Handbook containing this information to all householders at an early date.

Once the attack is over a quick return to the normal activities of the community is desirable, but before this is possible contaminated areas will have to be cleaned up. This work will be organised by local government, and the technique will not be discussed in this thesis.

All windows will be opened and fires lit to promote the free circulation of fresh air.

Public psychology is an increasingly determining factor in modern warfare. The threat of air attacks accompanied by the use of war gases constitutes an important psychological weapon which an unscrupulous enemy may employ. Military experience has shown that gas may be effectively countered by organised protection. Confidence in this fact on the part of the general public, coupled with assurance that adequate protective measures have been provided, will go far towards eliminating the threat of air gas attack. Careful planning and preparation to this end must

appeal to, and elicit, the co-operation of every public spirited citizen.

The public are also being taught that food supplies which become contaminated with liquid mustard or Lewisite, or which have remained for some time in a concentrated atmosphere vapour, are not safe for consumption. Such supplies of food should be taken out into the garden and buried.

While on this subject we are arranging with the wholesale food suppliers of the City some form of protection against gas. Up to the present the firms we have approached have shown great interest in the subject, and have undertaken to make their ware-houses gas-proof as far as possible.

CHAPTER XIX.

CHAPTER XIX.CONCLUSION.

In discussing the problem of Air Raid Precautions we have only made bare mention of such aspects as the decontamination of streets, decontamination of vehicles and the actual methods used to make buildings gas-tight and splinter-proof. These problems are not medical and are not administered by the Medical Officer of Health, and for this reason have not been fully described. They are however, fully as important as any of the other subjects which have been discussed.

Early in the thesis a very brief history of the Rules of War was given and we have seen how these Rules have been broken in the past. It has also been noticed, of late, how continental and American writers are beginning to defend the use of chemicals in war. The mere fact that gas is defended by writers of books must slowly influence certain numbers of their readers, and so the doctrine that chemical warfare is humane is bound to grow.

Prentiss in his book, Chemicals in War, writes a spirited defence of gas warfare. He says that after a careful study of this matter, and a close analysis of the casualties produced in the War, we know the facts concerning the effects of gas, and we see that much of the alleged horrors of gas warfare were pure propaganda deliberately disseminated during the World

War for the purpose of influencing neutral world opinion, and had little sincerity or foundation on fact. He goes on to say that gas causes less suffering than wounds from other weapons. He admits that chlorine did cause strangulation with considerable pain and high mortality when it was first used, but states that later when troops were supplied with gas masks, chlorine became the most innocuous of the toxic gases, and was the least feared by both sides.

The two other principal lethal gases, phosgene and chloropicrin, when employed in high concentrations, cause instant collapse with no suffering. With lower concentrations there is no pain. The pain caused by mustard gas is always delayed, and can often be avoided, and even where burns result the pain is not severe after twenty-four hours, although a man may be hospitalised for several weeks.

The ratio of deaths to total casualties is twelve times greater among those wounded by other weapons than among those afflicted by gas.

"Finally," he says, "as to the relative after-effects of gas as compared to other wounds, there can be no question. Gas not only produces practically no permanent injury, so that if a man who is gassed survives the war, he comes out body whole, as God made him, and not the legless, armless, or deformed cripple produced by the mangling and rending effect high explosives, gun shot wounds, and bayonet thrusts."

He finishes his defence by saying "the experience and statistics of the World War both indicate that it is not only one of the most efficient agencies for afflicting casualties, but is the most humane method of warfare yet devised by man."

While we do not entirely agree with this American writer in all he says, there is certainly a germ of truth in her argument. The doctrine is so well described, and so plausibly expressed that he is bound to get a large following, at least in his own native land. Thus we see as time goes on it is probable that gas will become a more and more important weapon, and there is no doubt that in organising a scheme of defence for civilian populations against air attack, the use of chemical agents must be prepared against.

Leicester's scheme is by no means completed and we realise that there is room for considerable improvement. It is hoped that in the near future we will be able to carry out a practice defence exercise similar to that held in the Southampton area in July last. We shall then be able to gather some slight idea as to how the scheme will work, even though conditions are bound to be somewhat unrealistic. We have endeavoured to cater for every possible situation or circumstance which might arise from the use of the known chemical warfare agents. If a new gas were produced, in all probability the scheme would

have to be modified, and new items of defence improvised.

Since the Great War, study of the medical aspects of gas warfare has been confined to the protection of the Defence Services. The development of aircraft has now however made it clear that in a future war no part of Great Britain would be immune from air attack. The protection of the civilian population against the effects of gas is therefore considered most essential.

Summary of Conclusions arrived at by the Author.

- (a) That in future wars in which Great Britain may be engaged, civil populations will not be exempt from attack from the air.
- (b) That sooner or later gas will be used during these attacks.
- (c) That an unprepared urban community is much more likely to be attacked than one which is prepared.
- (d) That a scheme for the protection of the public must be worked out in time of peace.
- (e) That the most important part of the scheme is the formation of an organisation for the prevention of unnecessary casualties, and for the treatment of actual casualties which may occur.
- (f) That the organisation of Air Raid casualty services should include arrangements for the collection and evacuation of the injured, improvisation of hospital

accommodation, training of personnel and provision of equipment.

(g) That to prevent panic and unnecessary alarm the public should be educated in all anti-gas measures.

(h) That it is considered to be a matter of national importance that all medical practitioners should have a sound knowledge of the effect of war gasses, and appropriate methods for their treatment. With this knowledge the doctor would be able to correct erroneous impressions in times of peace, and treat his patients with understanding should they become casualties in times of war.

(i) That we disagree with the policy of the Home Office in not attaching a doctor to the first aid posts. The responsibility of dealing with the situation is too great for St. John Ambulance Brigade Officers - excellent though they may be.

In conclusion the writer would like to emphasise that the larger portion of the work has been done as an official of the Leicester Corporation Health Department and that the Scheme has not yet been finally approved by the Corporation.

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IV.

APPENDICES.

A....Outline of Medical Scheme.

B....Equipment for First Aid Parties.

C....Map of Leicester showing position of:-

First aid depots.

First aid posts.

Casualty clearing hospitals.

Base hospitals.

Laundries.

D....Plan of Jarvis Street depot.

E....Scale of Accommodation for First Aid Posts.

F....Plan of Granby Halls First Aid Post.

G....Description and Diagram for Conversion of

Tradesmens Vans to Ambulance Vehicles.

V.

APPENDIX A.

Outline of Medical Scheme.

See Cylindrical Case.

VI.

APPENDIX B.

Equipment for First Aid Parties.

Each member of the party on duty should be equipped with:-

- Respirator.
- Protective clothing.
- First Aid pouch (see below.)

The party should also carry:-

- A stretcher (with oilskin cover in case of contaminated casualties)
- A blanket.
- Surgical haversack (see below)
- Spare Respirators (for casualties)

The suggested contents of the first aid pouch and surgical haversack, which should be of durable waterproof material, such as will withstand decontamination by approved methods, are:-

First aid pouch (one per man).

- 1 Triangular Bandage, unbleached calico, B.P.C., 38 in. x 54 in., wrapped.
- 1 White Open Wove Bandage, B.P.C., 1 in. x 3 yds., wrapped.
- 1 White Open Wove Bandage, B.P.C., 2 in. x 4 yds., wrapped.
- 1½ oz. Plain Lint, B.P.C., wrapped and cartoned.
- 1½ oz. Absorbent Cotton Wool, B.P.C., interleaved, wrapped and cartoned.
- 1 Pair Surgical Scissors, 5 in.
- 6 Safety Pins, nickel plated on brass, in metal container; size 3.
- 3 30 minim Ampoules, 2 per cent. Alcoholic Solution of Iodine, in card containers.
- 1 2 oz. Stoppered Bottle of Sal Volatile, in metal case.
- 1 2 oz. Graduated Medicine Tumbler, in strong container.
- 1 Piece strong Cane, 6 in. long.
- Elastic Plaster Dressings, assorted sizes, for minor injuries.

Surgical haversack (one per party)

- 1 Set Wooden Splints, with 3 metal pockets.
- 3 Cotton Webbing Straps for securing Splints.
- 1 lb. Cotton Wool, B.P.C.
- 2 Triangular Bandages, unbleached calico, B.P.C., 38 in. x 54 in. wrapped singly.
- 3 Elastic Plaster Dressings, for finger injuries, wrapped singly.
- 6 Elastic Plaster Dressings, for small wounds, wrapped singly.

VII.

- 1 Roll (3 yds.) of Gauze, B.P.C.
- 4 Large First Aid Dressings.
- 4 White Open Wove Bandages, B.P.C., 1 in. x 3 yds.
wrapped singly.
- 3 White Open Wove Bandages, B.P.C., 2 in. x 4 yds.
wrapped singly.
- 3 White Open Wove Bandages, B.P.C., 3 in. x 4 yds.
wrapped singly.
- 1 Spool Adhesive Plaster, Zinc Oxide, B.P.C., $\frac{1}{2}$ in.
x $2\frac{1}{2}$ yds.
- 12 Safety Pins, nickel plated on Brass, size 3, in
suitable container.
- 1 2 oz. Absorbent Cotton Wool, B.P.C., interleaved,
wrapped and cartoned.
- 1 1 oz. Boric Lint, B.P.C., wrapped and cartoned.
- 1 Pair Surgical Scissors, 5 in.
- 1 oz. 2% Alcoholic Solution of Iodine, in capillary
container.
- 1 2 oz. Graduated Medicine Tumbler, in strong con-
tainer.
- 1 Tourniquet, St. John's, or similar type.
- 1 Bottle Smelling Salts, or 6 Ampoules Aromatic
Ammonia, in container.

APPENDIX C.

Map of Leicester.

See Cylindrical Case.

IX.

APPENDIX D.

Plan of Jarvis Street Depot for First Aid Parties.

See Cylindrical Case.

APPENDIX E.

| | Large Post. | | Small Post. | |
|---|--------------|------------------------------|---------------|------------------------------|
| | Area of room | No. of patients at one time. | Area of room. | No. of patients at one time. |
| SECTION A (wounded or gassed, uncontaminated). | | | | |
| Room A.1 - Reception | sq. ft. | | sq. ft. | |
| Room A.2 - First aid | 450 | 16 | 250 | 8 |
| Room A.3 - Waiting | 600 | 12 | 400 | 8 |
| | 550 | 30 | 350 | 15 |
| | 1,600 | | 1,000 | |
| SECTION B (wounded or gassed and contaminated), | | | | |
| Room B.1 - Reception and undressing | 300 | 8 | 200 | 4 |
| Room B.2 - Washing and bleach treatment | 300 | 6 | 200 | 4 |
| Room B.3 - First aid | 300 | 6 | 200 | 4 |
| Room B.4 - Waiting | 350 | 12 | 250 | 6 |
| | 1,250 | | 850 | |
| SECTION C (unwounded Contaminated). | | | | |
| Room C.1 - Reception and undressing | 500 | 30 | 275 | 15 |
| Room C.2 - Washing and bleach treatment | 250 | 15 | 175 | 8 |
| Room C.3 - Dressing | 450 | 30 | 250 | 15 |
| Total for one sex | 1,200 | | 700 | |
| | 4,050 | | 2,550 | |

X:

Scale of Accommodation for First Aid Posts.

APPENDIX F.

Plan of Granby Halls First Aid Post.

See Cylindrical Case.

APPENDIX G.

GENERAL REMARKS.

Capacity: 2 Stretcher cases or 6 Sitting cases.

The ambulance is so designed that an Ambulance Party (6 to 8) can be conveyed with reasonable comfort from the point of assembly to the scene of action.

Material: All the wood used is of standard size and therefore merely needs cutting into suitable lengths.

| | | | |
|--------------|------------------------|----------------|----|
| <u>Cost:</u> | Wood | 7 | 7 |
| | 19 Angle irons 6" x 5" | 4 | 6 |
| | 2 Cabin hooks | | 10 |
| | Screws and nails | 1 | 0 |
| | 2 hrs labour | 3 | 0 |
| | | <hr/> | |
| | <u>Total cost</u> | <u>=16-11=</u> | |

Details of Labour.

Cut 6 blocks of 4" x 3" of a length about $\frac{1}{2}$ " less than the height of the wheel arches. Fix 2 angle irons to the 4 outer blocks as shown in Fig. A. and 3 angle irons to the two central blocks. Screw 3 of these blocks to the floor immediately behind the driver's seat and 3 to the floor at the tail of the van.

Nail a cross-piece of 4" x 1" across the top of each of the 2 series of blocks.

Nail 3 planks 7'6" long of 9" x 1" on each side and 1 in the centre) to the cross-pieces at either end as shown in Fig.B. These planks will project some 2' beyond the tail of the van floor.

Across these planks, about 6' from the fore-end, nail pieces of 1" x 1" as stops to prevent stretchers from running backwards. Similar strips of wood should be nailed along the central plank to prevent stretchers slipping sideways.

Fix the doors of the van to the projecting side planks by means of cabin hooks.

To make the whole structure rigid fix the planks to the panel or partition at the back of the driver's seat by means of 3 angle irons.

21.XII.37

DIAGRAM

Not to Scale.

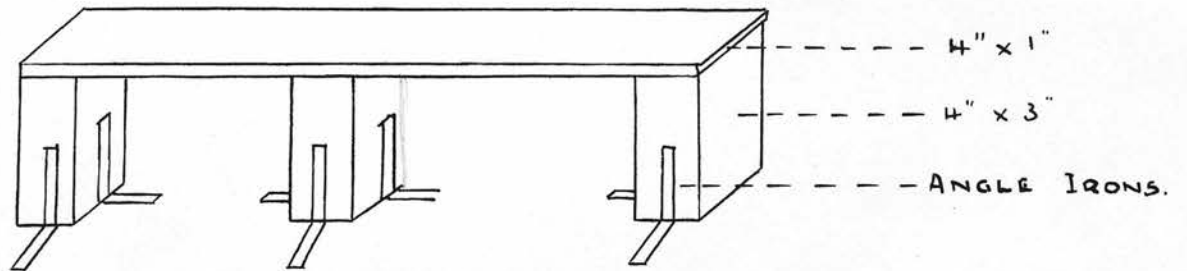


FIGURE 'A'

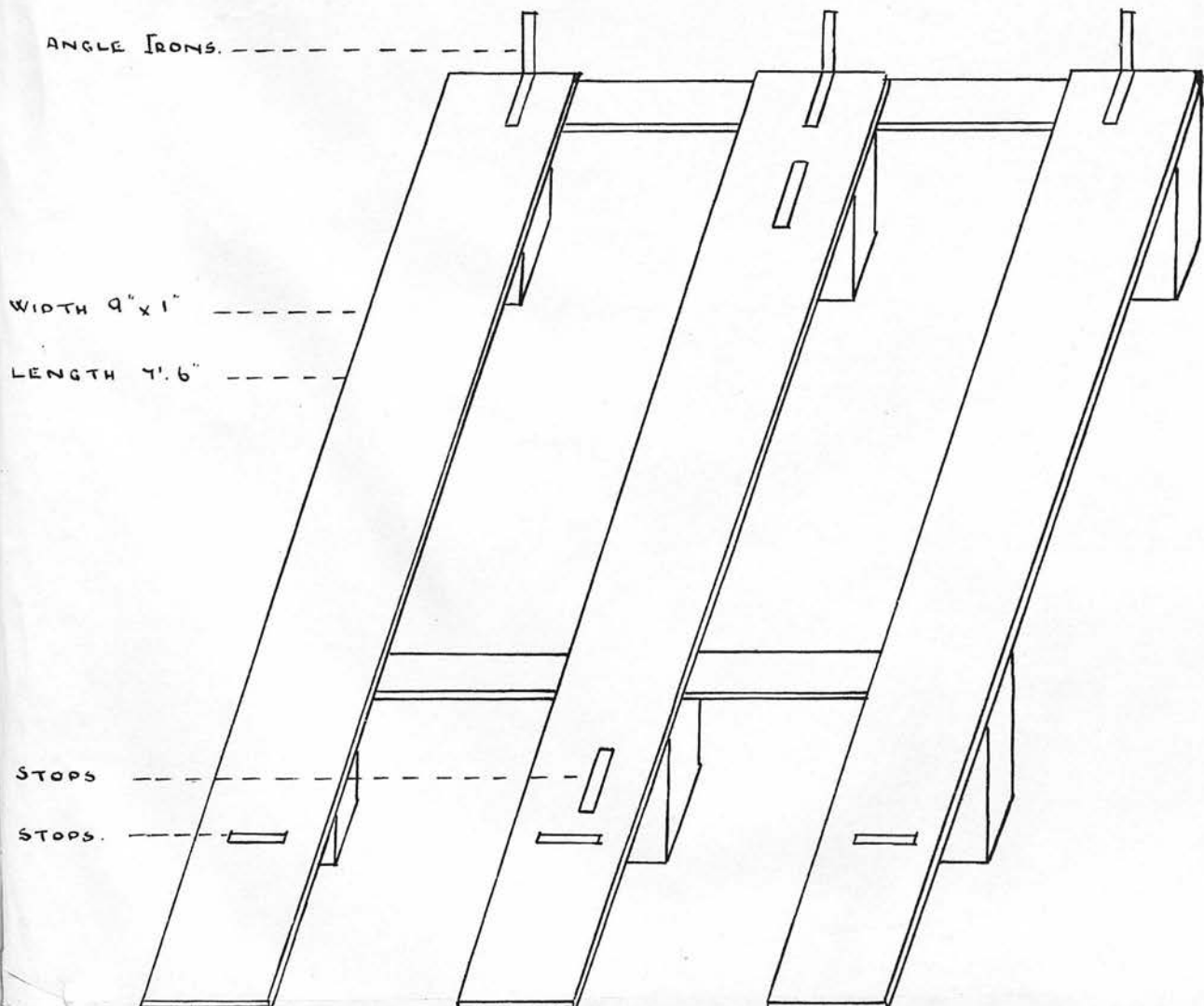


FIGURE 'B'